Evaluating the Effectiveness of Paper Modelling as an Active Learning Approach in the Musculoskeletal Module for the MBBS Students

Miral Nagy Fahmy Salama[1,*], Ramya Rathan[1] & Anusha Sreejith[2]

[1]Department of Biomedical Science, Gulf Medical University, Ajman, UAE

[2]Department of Community Medicine, Gulf Medical University, Ajman, UAE

*Correspondence: Department of Biomedical Science, Gulf Medical University, Ajman, UAE. E-mail: miralsalama@yahoo.com

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Abstract

Objective: Understanding the body's anatomical structures is critical for surgical safety and a crucial pillar of medical curricula, whether integrated or traditional. The students need to comprehend and memorize a significant amount of Anatomical information that seems to burden them. Hence, the paper modelling strategy is designed to help better learning with proper knowledge retention. Our study aims to assess the effectiveness of the modeling technique; concerning the students' performance and feedback at the module's conclusion.

Methods: The study used a quasi-experimental study involving 88 medical students who performed the paper modeling for seven weeks and included two weekly activity sessions. We used overhead projector sheets, color markers, and measuring tape for the students to create the muscle models and stick them to the skeleton with poster tack.

Results: Data analysis revealed that the students in the treatment groups achieved significantly higher scores (72.7%) than their peers (21.3 %), with a substantial disparity in the mean ratings between the two groups, $p<0.001$. Moreover, the students' feedback about this method showed that 70 to 73% agreed that the new approach helped them to comprehend and retain information about muscle locations, attachment sites, and actions and allowed them to have in-depth discussions with their peers.

Conclusions: The modeling method used in the current study was well appreciated by the students and enhanced their performance because it relied on the benefits of peer-to-peer instruction and embraced combined visual and kinesthetic learning styles.

Keywords: paper modelling, musculoskeletal system, small group anatomy learning, active learning

1. Introduction

Human Anatomy is an essential precursor in the medical program that is deemed significant to learn and even more challenging to recall. A thorough understanding of the human body's anatomical structure is critical for radiological diagnosis (Fileni, Fileni, Mirk, Magnavita, Nicoli, & Magnavita, 2013) and surgical safety (Turney, 2007) and Bergman, Van Der Vleuten, & Scherpbier, 2011). In addition, anatomy is the foundation for studying medicine (Fives, Lone, & Nolan, 2022) because it is a part of all medical curricula, whether integrated or traditional (Noorafshan, et al. 2014). Understanding the gross structure of the human body is necessary for understanding how the body functions (McCuskey, Carmichael, & Kirch, 2005)

Some integrated curricula may teach anatomy in pieces, and it is claimed that students no longer thoroughly understand the anatomy of the entire body. Moreover, due to the significant number of topics and skills to be covered in the undergraduate medical curriculum, anatomy is taught in less time (Bergman, Van Der Vleuten & Scherpbier, 2011). As a result, faculty members must choose appropriate instructional methods for delivering the content.

Learning anatomy by cadaveric dissection is essentially non-existent in most medical schools due to a scarcity of cadavers compared to the expanding student population (Chen, Zhang, Deng, Cai, Huang, Li, & Xiong, 2018). The active and engaging learning technique offers the student overall responsibility for and freedom to develop knowledge for themselves and their peers that are simple to grasp, remember, and recall. Furthermore, learners acquire confidence as they act as teachers to their peers (Senti, Miralles, Bigorra, Girvent, Minguella, Samso, Solsona, & Banos, 2015). Using such approaches in medical education has been shown in studies to increase medical students' critical, observational, and diagnostic skills (Edmonds, & Hammond, 2012) and (Shapiro, Rucker, & Beck, 2006).

In the last ten years, how human anatomy is taught has evolved significantly (Hoyek, Collet, Di Rienzo, De Almeida, & Guillot, 2014). Medical schools have had numerous changes, including introducing new teaching methods and the resulting difficulties (Majumder, 2004). An increasing number of models have been put forth to enhance the dynamic nature of instruction by considering different learning styles (Hussein, & Hussein, 2015). A growing number of students are employing innovative strategies, such as interactive lectures, computer-assisted learning, case-based learning (CBL), virtual patient learning (VPL), and problem-based learning (PBL) (Felder, & Brent, 2009). Active learning requires students to engage in creative activities and moves the focus of instruction from knowledge transmission to knowledge creation (Singh, Bharatha, Sa, Adams & Majumder, 2019)."Active learning" refers to anything requiring learners to do something rather than passively observe and listen during class (Fleming & Colleen, 1992). Incorporating these strategies into the classroom helps students become more engaged and excited about the subject matter.

For example, if students are visual learners, they prefer diagrams and mind maps; auditory learners, they like listening; and read-write learners, they like word list. However, kinesthetic learners prefer hands-on experience (Bigelow & Poremba, 2014). Additionally, it was determined that the student's visual and tactile recall was superior to their aural recall (Mueller & Oppenheimer, 2014) and hands-on learning activities promote long-term memory and create a more profound knowledge of the material, making it more pleasant (Prosser & Trigwell, 2017). Changing the methodology from a teacher-centered to a more student-centered approach may aid the student in comprehending the material, particularly in complicated modules such as the musculoskeletal system. Delivering a large amount of content harms the student learning experience (Kanchi, Junaid, Nandita, & Srikant, 2013). Learning in this atmosphere will never burden the student if the new knowledge is given engagingly. Teachers should be aware of their student's learning styles and be able to change accordingly rather than expecting pupils to conform to their teaching approach (Amin, 2020). Recent studies indicated that when content is accompanied by visual information, it is easier to recall since it lasts much longer in the memory than stuff that is merely heard or read (Vandan, Suzanne, Dooley, Clifford, Craig, & John, 2014). According to (Smith & Mathias, 2010) few students in some medical schools in the United States can pass the orthopedic exam, as much as 24.7%, due to inefficient musculoskeletal system teaching. Consequently, an effort was made to incorporate a new interactive, enjoyable way into the Musculoskeletal module to help students better comprehend the attachments of the various muscles in the body.

Singh et al. encouraged the students to use different forms of oral presentations that relied on poems, stories, and songs to address the muscular attachments, muscular motions, blood and nerve supply and applied anatomy of the limb musculature (Singh, Bharatha, Sa, Adams, & Majumder, 2019). Additionally, Naug et al. hypothesized hypothesized that drawing plays a crucial role in fostering metacognitive processes as students sequentially assimilate new information, and as a result, formative learning can be assessed more effectively using drawings (Naug, Colson, & Donner, 2011; Quillin & Thomas, 2015) and (Slominski, Momsen, & Montplaisir, 2017). For that to be achieved, students must recognize and recollect the necessary details they have learned throughout time in order to draw, after which they must create a "mental model" (Lyon, Letschka, Ainsworth, & Haq, 2013). The student's knowledge was inferred from their mental model, manifested in a physical task, "hand sketching" (Van Meter, & Garner, 2005). Drawing has its merits for promoting profound learning and long-term memory (Kumar & Rajprasath, 2019). However, there are some obstacles to incorporating progressive drawing into lectures, especially in classrooms with limited time. These may include diminished visual acuity in large classrooms and difficulty reading illegible chalkboard handwriting (Jabeen & Ghani, 2015). According to the data, students viewed these drawing screencasts favorably, and most felt they contributed to their learning (Greene, 2018). To address these deficiencies, medical education at the undergraduate level must adopt innovative methods to enhance the quality of musculoskeletal system instruction and learning (Stansfield, Diponio, Craig, Zeller, Chadd, Miller & Monrad, 2016).

The current study offers an active teaching strategy that utilizes paper models to examine students' performance.

2. Methods

2.1 Study Participants and Settings

An active and engaging learning technique was developed to aid in comprehending muscle attachment. This study used a quasi-experimental design and was perpetrated in the Anatomy division of the Gulf Medical University's Department of Bio-medical Sciences after getting approved by the Institutional Review Board.

The musculoskeletal module is seven weeks long and is included in phase 2 of the MBBS program. The study sampled third-year medical students at Gulf Medical University who were enrolled in the musculoskeletal module during the spring semester of 2019. The activity group had two weekly modelling sessions and two regular lab sessions. The control group consisted of medical students' performance in the musculoskeletal system during the fall 2018 semester that did not include paper modelling tasks but only had two regular laboratory sessions per week.

2.1.1 Objectives

i. To identify the effectiveness of paper modelling in enhancing student performance in the musculoskeletal module.

ii. To trace the students' feedback experience after practicing the paper modelling as a learning method.

2.1.2 Study Design

2.1.2.1 Modelling

The activity was divided into two weekly sessions: The first three weeks focused on the upper extremity, the fourth week on the head and neck, and the final three weeks on the lower extremity. The two sessions were scheduled this way after ensuring students had completed the theory and practical sessions, respectively. The students were randomly divided into eight small groups during the gross anatomy lab practical sessions. Each group received overhead projector sheets (OHP sheets), colored markers, poster tack, scissors, and a measuring tape. The students were then assigned to create paper models of muscles from a particular region using transparent paper and a measuring tape to determine the distance between the skeleton's attachment points. They had two hours to complete the modelling. Each muscle group was assigned a unique color code based on their direct action. Finally, the students were required to use the poster tack to accurately plot the formed muscle models to the skeleton at their attachment site, as shown in Figure 1. After completing their assigned task, students were asked to demonstrate the actions of various muscles and discuss the movement of multiple joints in a group competition setting.

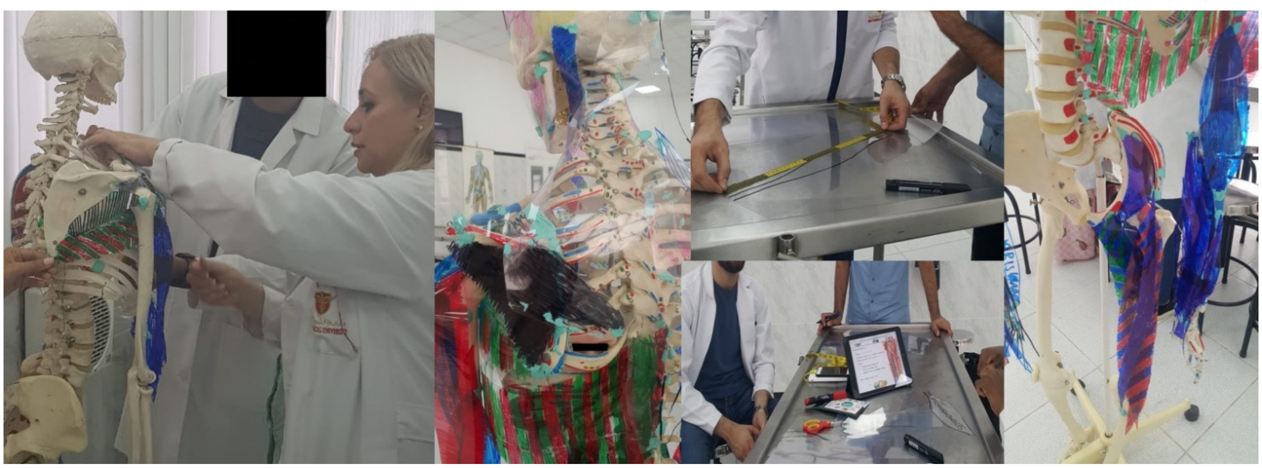

Figure 1. Small Groups of Students During Modelling Sessions

2.2 Data Collection

2.2.1 Students Performance

In the control and experimental groups, specific marker multiple-choice questions were used to assess student performance on the end module theory examination. The exam was administered the following week following the conclusion of the course. There were 22 questions, with one point awarded for each correct response and zero points awarded for each incorrect answer. For each group, the median score was calculated. Students with a total score more significant than the median were considered high scorers, while those with a total score less than the median were considered low. Students' grades, marker questions, and questionnaires were stored at Gulf Medical University's College of Medicine.

2.2.2 Students' Feedback

Following the study's conclusion, the authors allotted a feedback questionnaire validated by two experts to students to collect data on their experiences. In addition, six closed-ended questions about the activity were included in the Questionnaire.

2.2.3 Statistical Analysis

SPSS 26 software was used to conduct the statistical analysis. Frequencies and percentages were calculated to ascertain the students' experience with the paper modelling method. Mann-Whitney U test was used to assess if there was a significant difference in the scores between the group subjected to the activity and the group not.

3. Results

3.1 Relationship of the Method with Student Scores

The distribution of the scores according to the groups is shown in Table 1. The median of the scores is 14. After the analysis of the data, it was revealed that there was a statistically significant association found between the experimental and control groups with the test scores. The experimental group students scored significantly higher (72.7%) than their counterparts (21.3%).

Table 1. Association between Groups and Score

Groups	Low scorers		High scorers	
	*%	*N	%	N
Experimental Group	27.3	24	72.7	64
Control Group	78.7	70	21.3	19

* % is the percentage of the low scorers, and (*N) is the number of the low scorers' students.

% is the percentage of the high scorers, and (N) is the number of the high scorers' students

Mann-Whitney U test was applied to find whether there was any significant difference between the mean scores in the two groups. From Table 2, it was concluded that the scores in the experimental group were statistically significantly higher (116.23) than in the control group (62.08), $p<0.001$.

Table 2. Mean Scores in the Experimental and Control Groups

Groups	N*	Mean Rank	P value
Experimental Group	88	116.23	<0.001
Control Group	89	62.08	

* N is the number of students in each group

3.2 Experience of the Students

These sessions were attended by 89 students who had been registered for the module. Almost 67.5 percent agreed that memorizing and comprehending the musculoskeletal module solely through lecture and practical sessions were challenging. However, around 70.8 percent of study participants affirmed that this type of active learning method enabled them to have more in-depth discussions about muscle attachments and actions with their peers. Seventy-three percent of students agreed that graphing the skeleton muscles aided their comprehension and retention of the information. In addition, 70.8 percent of students admitted that this method helped them correctly imagine each muscle's location. Moreover, 70.4 percent of students agreed that this method assisted them in identifying muscle attachment sites. Finally, most students suggested that this technique be used for junior batches, as shown in Table 3.

Table 3. Responses to the Statements Provided by the Students Through the Questionnaire

Questionnaire	Neutral	Strongly Disagree	Disagree	Agree	Strongly Agree
Learning the anatomy of the Musculoskeletal module is difficult.	14.6	4.5	13.5	50.6	16.9
Paper modeling makes students recognize the sites of muscle attachments.	15.9	4.5	9.1	42	28.4
Paper modeling makes students correctly imagine where the muscle is located.	14.6	3.4	11.2	39.3	31.5
Paper modeling makes students realize how the muscles are related to each other.	20.2	1.1	10.1	40.4	28.1
Paper modeling helped students discuss more of the attachments and actions with colleagues.	13.5	3.4	12.4	41.6	29.2
Coloring code helped students memorize the attachments after the end of sessions.	16.9	0	20.2	38.2	24.7
Paper modeling and plotting the different muscles on the skeleton help better understand and retain information.	13.5	1.1	12.4	44.9	28.1
Prefer to attend an anatomical class taught with this method	13.5	3.4	18	34.8	30.3
Suggest using this method again	13.5	5.6	12.4	36	32.6

4. Discussion

New techniques are being introduced to encourage students to learn more actively (McMenamin, 2008). However, a robust outlook toward the classical teaching methods persists among teachers, and Interactive Techniques in anatomy education in theory classes have received little attention (Dueñas, & Finn 2020) and (Hackathorn, Solomon, Blankmeyer, Tennial, & Amy 2011). Deciding which pedagogical system to use as the most appropriate method to teach anatomy is the most challenging part faced by the instructor. Anatomical information on the musculoskeletal system is considered one of the most challenging systems for students to learn and remember, making it appear like a burden. Hence, there is a need to construct an active learning method where the student will have hands-on experience with the different skeleton bones, exploring their features, and then plotting the muscle's models correctly in the correct place and relation to each other. In summarizing the results, it was evident that there was a significant difference between the control and the treated groups of students who participated in this activity. This finding is consistent with Hackathorn et al.'s assertion that the higher grades were attributable to active learning techniques such as in-class activities (Hackathorn, Solomon, Blankmeyer, Tennial, & Amy 2011). In addition, Hattie discovered that peer learning is 59% more effective than individualistic learning because collaborative learning increases student interest and peer influence (Hattie, 2009).

Moreover, the better performance in the present study is comparable to that reported by Cookson through employing body painting to learn anatomy since it relies on a combination of visual and kinesthetic modalities, which has eventually enhanced knowledge retention (Cookson, Aka & Finn, 2018) and (Correia, Baatjes, & Meyer, 2022). Furthermore, the suggested method improved student performance, consistent with Naug et al., and Quillim et al., who reported improved student performance after using drawing activity for learning anatomy (Naug et al., 2011), (Quillin et al., 2015) Also concordant with Correia et al., who reported similar results after employing clay modelling in studying anatomy (Correia et al., 2022) and (Joewono, Karmaya, Wirata, Widianti, Wardana, & Yuliana, 2018)

Whether the objective is to increase student comprehension of content, develop specific transferable skills, or a combination of the two, instructors frequently use small group work to maximize the benefits of peer-to-peer instruction (Brame, 2019) and (Van Meter, & Garner, 2005). Model-based reasoning analyses complex and abstract concepts (Finn, 2018). Our study aimed to determine paper modelling's efficacy in improving student performance and tracing students' perceptions of it. Receiving favorable student impressions and feedback for this new activity is similar to what was reported by Senti et al., who explained the cause of students' satisfaction due to the acquired confidence as they act as teachers to their peers (Senti et al., 2015) and their feelings that they are actively contributed to learning (Greene, 2018)

Paper modeling appeared to be the most cost-effective method. The OHP sheets used in this study are economical, and the stationery used, such as colored markers, poster tack, scissors, and measuring tapes, is reusable. Employing less fancy study materials than technology is critical for any institution considering adopting teaching methods (Finn, 2018).

While most of the educators' attention is currently focused on new technology and software programs that students often access via their phones or laptop, recent research indicates that students preferred tutor-led sessions over self-directed sessions because they were unwilling to pay for them on their own devices (Meyer, Stomski, & Losco, 2016). Moreover, the navigation and abundance of options in multimedia and simulation software bombard students' cognitive processing capabilities, impairing learning (Kirschner, 2002). The ability of these applications to provide students with an excessive number of views of anatomical structures distracts them from focusing on critical information (Levinson, Weaver, Garside, McGinn, & Norman, 2007). Furthermore, in their review, Samy and Sarah looked at 30 studies to see how 3D Anatomy Software affected student learning. They used the Medical Education Research Study Quality Instrument to assess the research's quality (MERSQI). Most studies were of moderate quality, and there was no conclusive evidence that 3D models are better than traditional instructional strategies (Azer & and Azer, 2016).

All in all, most students in our study reported that using paper models helped them recognize muscle attachment sites, visualize where the muscle was located, and how the muscles were related to one another. This method also helped the students to comprehend muscle attachments by integrating multiple learning styles and approaches. Students visualized, plotted, and recited the instructions (auditory) while visualizing and plotting the paper models on the skeleton (kinesthetic). Student enjoyment fosters a positive learning environment, and peer-led education frequently produces positive results (Nanjundaiah & Chowdapurkar, 2012).

5. Conclusion

This research is the most comprehensive examination of using paper models to teach and learn musculoskeletal anatomy because it proposes a novel, simple entertaining way for enhanced learning and retention. Hence, the activity offers a pleasant diversion from traditional learning environments such as the dissecting room or lecture hall. The findings of this study should persuade educators to utilize numerous ways of knowledge presentation. Its use may require instructors to deviate from their favored method(s) of instruction and learn to employ a variety of styles, which will favorably enhance student learning.

6. Conflicts of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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Authors contributions

Dr. Miral Salama was responsible for study design, collecting the samples, drafting the manuscript and reviewing final manuscript. Dr. Ramya Rathan was responsible for collecting samples and drafting the manuscript and Dr, Anusha Sreejith was responsible for drafting the statistical part of manuscript.

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No additional data are available.