# Using 3Dimensional Teaching in Biomechanics for Physiotherapy Education at Ahfad University for Women, Sudan.

**Hassan Abdelnour[1]\*, Nermeen Bleedy[1], Abdulmajeed Almalty[3], Asrar Elkhir[3], Maria Ayoub[4]**

[1,\* 2] Physiotherapy Department, Faculty of Allied Medical Sciences, Jerash University, Jerash, Jordan.
[3] Department of Physical and Occupational Therapy, College of Allied Health Sciences, the Hashemite University, Zarqa, Jordan.
[4] Physiotherapy Department, School of Health Sciences, Ahfad University for Women, Omdurman, Sudan

## Abstract

**Introduction**: While many teaching strategies have been used within healthcare-related coursework, there is a lack of literature in physiotherapy education describing the use of 3Dimensional learning method for teaching biomechanical concepts of the knee joint. Among difficult concepts that may benefit from alternative teaching strategies is the knee joint which is the main lower limb motor joint, and the most vulnerable and susceptible joint to injury.

**Methods**: Randomized Control Trial (RCT) study design was conducted among 3rd, 4th, and 5th-year physiotherapy students from Ahfad University for Women (AUW). The sample included 74 students of all three years; 35 students in the control group, 39 students in the experimental group. The Control group underwent the traditional way (normal lectures by PowerPoint including 2Dimensional images) of learning knee joint biomechanics, while the experimental group has undergone the 3Dimensional learning method using 3Dimensional knee joint model. Knowledge on biomechanics for both experimental and control groups was assessed using a test and satisfaction towards the 3Dimensional learning method among experimental group was determined using a questionnaire.

**Results**: The results revealed that students in the experimental group scored higher marks compared to students in the control group (37 students (61.6%), 23 students (38.4%) respectively) with a significant association between tests scores and group (P = 0.001).

**Conclusion**: the study concluded that using the 3dimensional knee joint model as a teaching aid has improved biomechanical knowledge for Undergraduate Physiotherapy Students at AUW.

**Keywords:** 3D-model, Students, Knee.

## 1. Introduction

World Conference of Physio Therapy (WCPT) recognizes, understands and values the fact that education of physical therapists is complex and occurs in a constantly changing environment. Therefore, the initial and continued education of physical therapists must equip them with the skills and attributes to perform in such an environment [1]. One of the best interactive/participative teaching methods which inspire medical students to think for themselves and become more independent learners are 3D-models [2], and they have been used in many medical areas ranging from accurate replication of biomechanics and pathology to assist pre-surgical planning and simulation of complex surgical or interventional procedures, serve as a useful tool for the education of medical students and patients, and improve doctor-patient communication [3]. The main lower limb motor joint, the most vulnerable and susceptible joint is the knee joint, as the knee injuries considerably impact the normal living ability and mental health of patients. Understanding the biomechanics of a normal and diseased knee joint is in urgent need for designing knee assistive devices and optimizing a rehabilitation exercise program [4].

## 2. Methods

Randomized Control Trial (RCT) study design has been used, it was a Purposive sampling in which an overall of 74 Students have been divided randomly into 35 students in the control group, 39 students in the experimental group using Microsoft Excel 2010 to receive 1 of the 2 educational interventions. As the control group undergone traditional way of learning knee joint biomechanics using PowerPoint lecture that included pictures of the knee joint and theoretical explanation about the topic, while the experimental group undergone a 3Dimensional learning method that included a 3Dimensional knee joint movable model, to explain the topic with the same content as that of the control group, along with visualizing and manipulation of the knee joint structures and motions from all views; front, back and side direction. The study has been conducted in Omdurman-Arda Street, AUW, physiotherapy department were the included criteria were 3rd, 4th, and 5th-year physiotherapy students from Ahfad University for Women who agreed to participate on this study as they accomplished the biomechanics course, 2nd year students were excluded as they haven't undergone the biomechanics course. All data expressed as Statistical Package for the Social Sciences (SPSS) (version 24) for statistical

analysis, as it was accessible and it's used by various kinds of researchers for complex and comparative statistical data analysis. SPSS was used as a method to analyze the results obtained from the knee joint exam provided to students; these results were used to describe the improvement in their knowledge after using the 3Dimensional knee joint model. The timeframe for conducting this study was 4 weeks.

## 3. Results

***Section A: Criteria of the students included in the study*** (Educational Year of students in the study, Group divisions of students in study)

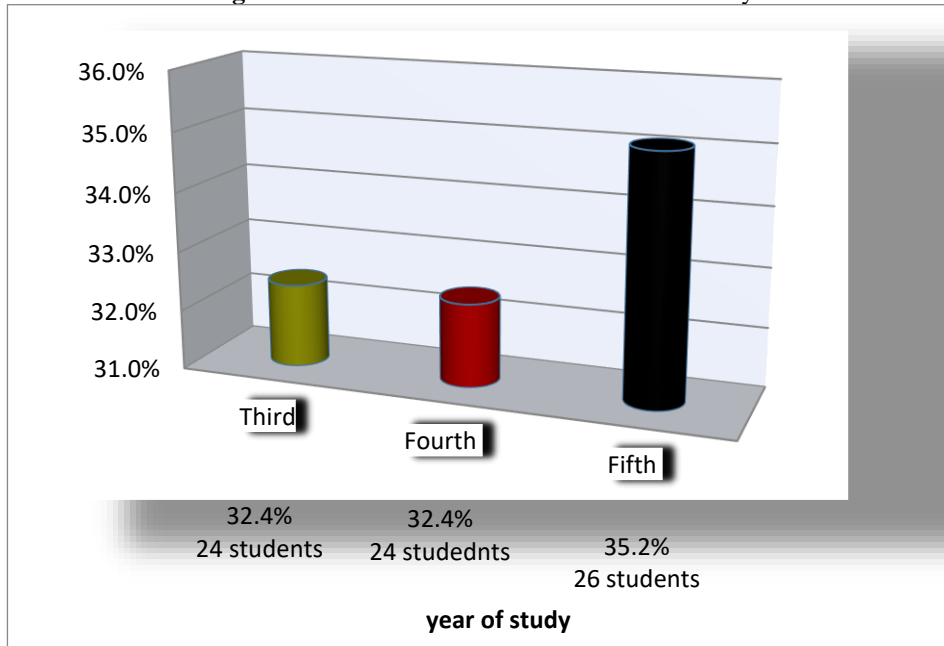**Figure 1** Educational Year of Students in the study



Figure 1 show that 26 students (35.2%) were at fifth university year, while students at third and fourth years were represented by equal portions 24 students (32.4%) from third year and 24 students (32.4%) from fourth year.

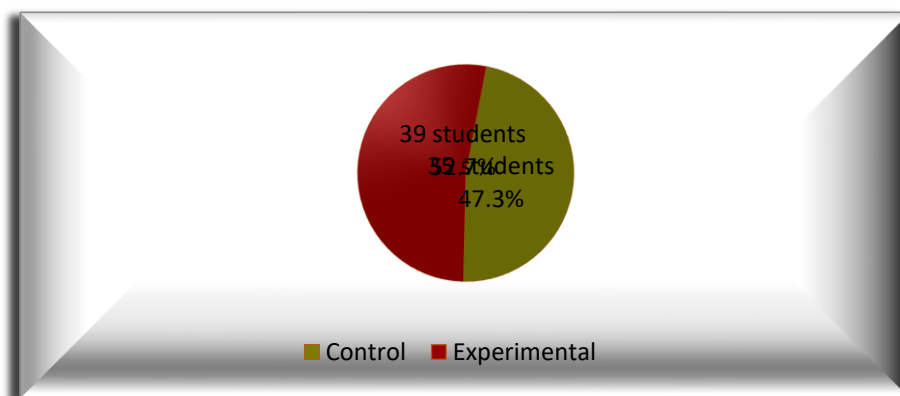**Figure 2** Group division of study



Figure 2 illustrate that 39 students (52.7%) were included in the experimental group, while 35 students (47.3%) were in the control group.

***Section B: knowledge of undergraduate physiotherapy students regarding knee joint biomechanics using exam*** (Test scores, Comparison of test scores between control and experimental group, Distribution of the students according to their answers on questions regarding 3d knee model exam)
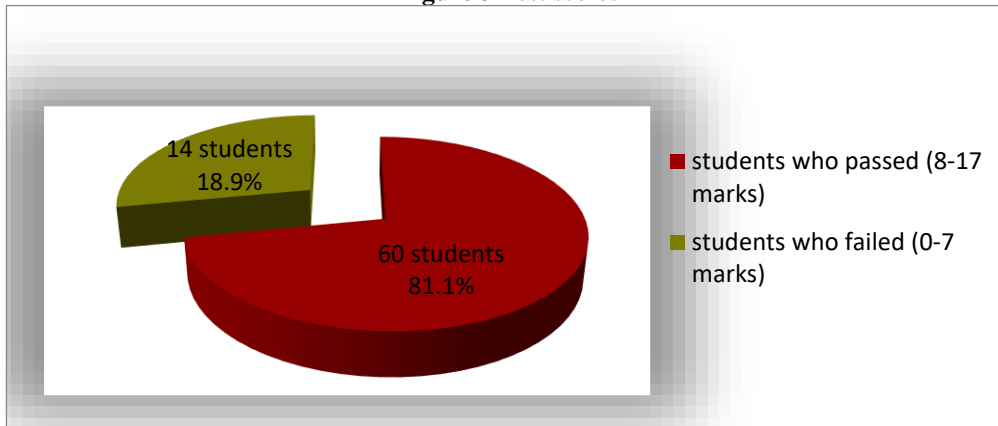
**Figure 3** Test scores



Figure 3 illustrates test scores from both groups; Control and experimental that ranged between 4-17 marks, with a mean of 10.78 marks. 60 of students (81.1%) passed the exam, while 14 of the students (18.9%) failed.

**Figure 4 Comparison of test scores between control and experimental groups**
P value = 0.001
Figure 4 shows that students in experimental group, 37 students (61.6%) scored higher marks compared to students in the control group 23 students (38.4%). The results revealed a significant association between tests scores and group.

**Table 1** Distribution of the students according to their answers on 3Dimensional knee joint model exam:

| Exam questions: | Experimental Group: | | | Control Group | | |
|---|---|---|---|---|---|---|
| | Correct answer | Wrong answer | Total | Correct answer | wrong answer | Total |
| Q1: A)   Knee joint is a biaxial joint (      ) | 21 | 18 | 39 | 17 | 18 | 35 |
| | 53.8% | 46.2% | 100% | 48.5% | 51.5% | 100% |
| B) Posterior cruciate ligament prevents hyperextension of knee ( ) | 16 | 23 | 39 | 8 | 27 | 35 |
| | 41.1% | 58.9% | 100% | 22.8% | 77.2% | 100% |
| C) During knee extension in open kinetic chain the Tibia glides anteriorly on the femur surface   ( ) | 26 | 13 | 39 | 17 | 18 | 35 |
| | 66.6% | 33.4% | 100% | 48.5% | 51.5% | 100% |
| D) During knee flexion in closed kinetic chain the femur condyles becomes more anteriorly in this position (      ) | 20 | 19 | 39 | 9 | 26 | 35 |
| | 51.3% | 48.7% | 100% | 25.7% | 74.3% | 100% |
| Q2:    A)   Medial   condyle articulating   surface   is _____ in size than lateral condyle articulating surface a) Larger   b) smaller | 37 | 2 | 39 | 26 | 9 | 35 |
| | 94.8% | 5.2% | 100% | 74.3% | 25.7% | 100% |
| B) Viewing  the  knee  joint from a sagittal plane, the Tibia articulating   surface   is _____ a) Convex  b) Concave | 29 | 10 | 39 | 22 | 13 | 35 |
| | 74.4% | 25.6% | 100% | 62.8% | 37.2% | 100% |
| C) During knee flexion in closed kinetic chain femur glides _____ on tibia a)Anteriorly     b) Posteriorly | 22 | 17 | 39 | 23 | 12 | 35 |
| | 56.5% | 43.5% | 100% | 65.7% | 34.3% | 100% |
| Q3: A) In locking mechanism of the knee joint, the femur rotates i)_____ , | 33 | 6 | 39 | 19 | 16 | 35 |
| | 84.6 | 15.4 | 100% | 54.3% | 45.7% | 100% |

| Question | Exp correct | Exp incorrect | Exp total | Control correct | Control incorrect | Control total |
|---|---|---|---|---|---|---|
| ii) _____ , | 33 (84.6%) | 6 (15.4%) | 39 (100%) | 21 (60%) | 14 (40%) | 35 (100%) |
| while the tibia rotates iii) _____ , | 32 (82.1%) | 7 (17.9%) | 39 (100%) | 20 (57.2%) | 15 (42.8%) | 35 (100%) |
| and iv)_____ | 34 (87.2%) | 5 (12.8%) | 39 (100%) | 20 (57.2%) | 15 (42.8%) | 35 (100%) |
| B) Patellofemoral joint is a saddle joint between i) _____ | 26 (66.6%) | 13 (33.4%) | 39 (100%) | 3 (8.5%) | 32 (91.5%) | 35 (100%) |
| and ii)_____ | 34 (87.2%) | 5 (12.8%) | 39 (100%) | 24 (68.5%) | 11 (31.5%) | 35 (100%) |
| C) Internal and external rotation of the Tibia appears in the _____ plane. | 24 (61.5%) | 15 (38.5%) | 39 (100%) | 22 (62.8%) | 13 (37.2%) | 35 (100%) |
| Q4: A) Tightness of which knee joint ligament leads to the pathological condition "Knock knee"? | 18 (46.2%) | 21 (53.8%) | 39 (100%) | 17 (48.5%) | 18 (51.5%) | 35 (100%) |

Q5: name the labeled part and tell if it is the right or left knee joint.



| Question | Exp correct | Exp incorrect | Exp total | Control correct | Control incorrect | Control total |
|---|---|---|---|---|---|---|
| This labeled part is i) _____ | 37 (94.8%) | 2 (5.2%) | 39 (100%) | 30 (85.7%) | 5 (14.3%) | 35 (100%) |
| And this is the ii) _____ knee | 31 (79.5%) | 8 (20.5%) | 39 (100%) | 17 (48.5%) | 18 (51.5%) | 35 (100%) |

Table 1 illustrates the difference between two groups answering the exam questions; as shown,
Significant points the table shows; In Question 2: A; 37 students (94.8%) from experimental group answered it correctly, while only 26 students from the control group (74.3%) answered this question correctly.
In Question 3: B, I; 3 students (8.5%) from the control group answered this question correctly compared to 26 students (66.6%) from experimental group answered this question correctly.

## 4. Discussion

**Test scores**

Exam questions included different forms of questions targeting different students with various mental abilities (memorizing, visualization, imagination, scientific reasoning) as it included 5 different question forms; (true and false questions, multiple-choice questions, fill in the blank, answer the following question, Name the labeled part). 60 of the students scored 8 marks and more, while 14 of the participants scored less than 8 marks from both experimental and control groups, making the percentage of success higher than that of failure (81.1%, 18.9% respectively) between participants of both groups.

Noguera *et al* (2013), done a similar study stated that regarding the first practical lesson (about the knee and ankle), the mean value and standard deviation of the first post-test scores were 6.87 0.8 for the experimental group and 4.8 0.8 for the control group [5]. According to the t-test result, a significant difference was found between the two groups. The mean

difference between groups was 2.07 (95% CI: 1.66–2.47) in a range of 0–8. Considering that 100% corresponds to the eight questions answered correctly, this suggests a significant increase of over 25% of learning achievement for the experimental group. In this case (a practical lesson about the knee and ankle) the proposed 3D manual-learning tool was more effective than classical teaching methodology

**Comparison of test scores between control and experimental groups**

 Participants in the experimental group got higher marks compared to those in the control group (37 students (61.6%) , 23 students (38.4%) respectively), and that is related to the fact that visualized information is memorized easier and lasts longer in Students' memory making it easier in the clinical setting and practice.

Similar results were also obtained by Cai et al., (2019), who stated that the utility of the 3D printed simulator was evaluated in comparison with traditional didactic learning in first-year medical students ($n = 35$), so as to understand how the functional 3D simulator could assist in their learning of human anatomy [6]. The outcome measure was a quiz comprising 11 multiple choice questions based on locking and unlocking of the knee joint. Students in the simulation group (mean score = 85.03%, ±SD 10.13%) performed significantly better than those in the didactic learning group, $P < 0.05$ (mean score = 70.71%, ±SD 15.13%). In terms of learning outcomes, female students who used 3D printed simulators as learning aids achieved greater improvement in their quiz scores as compared to male students in the same group. However, after correcting for the modality of instruction, the sex of the students did not have a significant influence on the learning outcome. This randomized study has demonstrated that the 3D printed simulator is beneficial for anatomical education and can help in enriching students' learning experience.

## 5.    Conclusion

The current study was carried out among 74 physiotherapy students at AUW, the purpose of this study was to assess the educational effect of 3Dimensional knee model as a teaching aid in improving biomechanical knowledge for undergraduate physiotherapy students at AUW, where (26 students, 35.2%) of the students were at fifth university year, while 24 students (32.4%) at third year and 24 students (32.4%) from fourth year. 3D knee joint model teaching method was used for teaching biomechanics, it was applied among 39 (52.7%) students of the experimental group while the other group (control) 35 students (47.3%) received biomechanics course using only the traditional method (PowerPoint, 2D-imaging). A test that examines the physiotherapy students' biomechanical knowledge was carried out among the two groups after the lectures given. Results indicated that the students in the experimental group who received 3Dimensional knee joint teaching method scored higher marks compared to students in the control group who received traditional way of lecturing (37 students (61.6%), 23 students (38.4%) respectively).

## 6. Recommendations

According to the study findings, study recommends the following:
- 3Dimensional Knee Joint Model should be used as a Teaching Aid, particularly, for Undergraduate Physiotherapy students to improve their knowledge, to achieve the learning outcomes and accreditation requirements of their course.
- Educational methods and practice need deep attention and development to use the full potential of the visualization concept in the learning process, especially for the health care professions.
- Further studies on using visualization and functional models in broader areas of medical education should be carried out. The effects of these models on student's grades within physiotherapy and other related health courses should also be investigated.
- Further researches should be applied concerning the 3D teaching method using printed models rather than plastic models if possible.

## 7. Strengths of the study

This study was the first study to be done in Khartoum targeting not only exercises that physiotherapist provide but instead by getting out future physiotherapists who are fully aware of biomechanical motions of the joint, it also gives an overview of total knowledge about Knee joint and satisfaction using the 3Dimensional model.
Also, that our sample size was big which decreased from the result errors.

## 8.    Limitation of the study

The results were seen in AUW only and not in other universities as well; therefore the results aren't generalized for all physiotherapy students in Khartoum State.

Some scientific websites were blocked during the COVID-19 crisis; it limited our resources, and was challenging to recite journals at that time.

**References**

WCPT. (2021). World.physio. Retrieved 18 September 2021, from https://world.physio/sites/default/files/2020-04/PS-2019-Education.pdf.

Heather, H. (2021). 7 Effective Teaching Strategies for the Classroom - Blog | Quizalize. Blog | Quizalize. Retrieved 18 September 2021, Available at: https://www.quizalize.com/blog/2018/02/23/teaching-strategies/.

Aimar, A., Palermo, A., & Innocenti, B. (2019). The Role of 3D Printing in Medical Applications: A State of the Art. Journal of Healthcare Engineering, 2019, 1-10. DOI: 10.1155/2019/5340616

Zhang, L., Liu, G., Han, B., Wang, Z., Yan, Y., Ma, J., & Wei, P. (2020). Knee Joint Biomechanics in Physiological Conditions and How Pathologies Can Affect It: A Systematic Review. Applied Bionics And Biomechanics, 2020, 1-22. DOI: 10.1155/2020/7451683

Noguera, J., Jiménez, J., & Osuna-Pérez, M. (2013). Development and evaluation of a 3D mobile application for learning manual therapy in the physiotherapy laboratory. Computers & Education, 69, 96-108. DOI: 10.1016/j.compedu.2013.07.007

Cai, B., Rajendran, K., Bay, B., Lee, J., & Yen, C. (2019). The Effects of a Functional Three-dimensional (3D) Printed Knee Joint Simulator in Improving Anatomical Spatial Knowledge. Anatomical Sciences Education, 12(6), 610-618. DOI: 10.1002/ase.1847

**Authors profile:**

**1- Hassan Abdelnour.**



Assistant Professor, Physiotherapy Department, Faculty of Allied Medical Sciences, Jerash University, Jerash, Jordan. Email contact: hasphysio@gmail.com  ORCID ID: https://orcid.org/0009-0001-9873-5966

**2- Nermeen Bleedy.**



Assistant Professor, Physiotherapy Department, Faculty of Allied Medical Sciences, Jerash University. Jerash, Jordan. Email contact: edinermo@gmail.com  ORCID ID: https://orcid.org/0009-0003-5804-9448

**3- Abdulmajeed Almalty.**



Associate Professor, Department of Physical and Occupational Therapy, College of Allied Health Sciences, the Hashemite University, Zarqa, Jordan.Email contact: abedm2001@yahoo.com
ORCID ID: https://orcid.org/0000-0003-1521-731X

**4- Asrar Elkhir.**



Physiotherapy Department, School of Health Sciences, Ahfad University for Women, Omdurman, Sudan.
Email contact: asrarelkhhir1998@gmail.com
ORCID ID: https://orcid.org/0009-0007-4948-3372

**5- Maria Ayoub.**



Physiotherapy Department, School of Health Sciences, Ahfad University for Women, Omdurman, Sudan.
Email contact: maria.ayoub.333@gmail.com
ORCID ID: https://orcid.org/0000-0009-4990-6499