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Shobha Chikkavaddaragudi Ramachandra
Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research

Vivek Anand Ojha
Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research

Devananda Devegowda
Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research

Suma M Nataraj
Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research

Prashant Vishwanath
Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research

See next page for additional authors

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Cover Page Footnote

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Authors

Shobha Chikkavaddaragudi Ramachandra, Vivek Anand Ojha, Devananda Devegowda, Suma M Nataraj, Prashant Vishwanath, and Akila Prashant

ORIGINAL STUDY

3-Dimensional Model Making as an Innovative Tool for Enhanced Learning Through Student Engagement Among Early Professional Medical Graduates

Shobha Chikkavaddaragudi Ramachandra, Vivek Anand Ojha, Devananda Devegowda, Suma M. Nataraj, Prashant Vishwanath, Akila Prashant*

Centre of Excellence in Molecular Biology & Regenerative Medicine, Department of Biochemistry, JSS Medical College, JSS Academy of Higher Education & Research, India

Abstract

Background: **Various innovative teaching-learning methods have been introduced in the medical curriculum for a better understanding of the difficult topics. We introduced the 3-dimensional (3D) model-making as an innovative tool for enhanced learning through student engagement among early professional medical graduates.**

Methods: **The study was conducted in the Department of Biochemistry of a Private Medical College. The phase I medical undergraduate students were divided into 20 groups with 10 students in each group. The topics taught by didactic lectures were allotted to each group by lottery method and were informed that the best model will be suitably rewarded after evaluation. Feedback was collected from the students on a five-point Likert scale after the submission and evaluation of the models.**

Results: **About 92% of the students expressed that 3D model-making was an innovative method of learning in the medical profession, and 96.3% agreed that the topics allotted were relevant to the syllabus and helped in better understanding of the subject when compared to didactic lectures. The students also agreed that the 3D model-making activity enhanced their creativity and application of knowledge to learn biochemistry, developed a positive attitude, helped to coordinate with their peers, and improved communication skills. They suggested that this activity should be continued with the inclusion of more topics.**

Discussion: **The 3D model-making activity helped the students to enjoy learning, think differently, understand better, expand their knowledge and recall information more comprehensively.**

Keywords: Model-making, Innovative teaching method, Enhanced learning, Biochemistry

1. Background

Universities are the birthplaces of new ideas seeded by knowledge, creativity & innovation mastered by learning. Knowledge & Learning can never live in disparity to each other, they are like pollex, and the rest of the four fingers, always function in synchronization. In recent years, medical universities globally are striving toward bringing innovations in medical education that will inculcate the problem-solving culture among undergraduate students.

Anatomy, Physiology & Biochemistry are the building block for the entire medical career generally taught in the first phase of the medical curriculum. Teaching and learning biochemistry is one of the greatest challenges in the undergraduate curriculum. It is only recently that the National Medical Commission of India (NMC) has proposed major changes in the teaching-learning methodology of the medical curriculum [1] to bring about active and self-directed learning culture among the students. Else, teaching-learning and assessment methods have not changed much to meet the emerging needs

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* Corresponding author.
E-mail address: akilaprashant@jssuni.edu.in (A. Prashant).

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of the students and society in India for a long time [2]. For decades biochemistry is taught primarily through didactic lectures. The didactic method is one of the basic components of education and helps to understand the existing knowledge; broaden the ideas and direct to point out things of value; achieve educational objectives; evolve the process of education and attain the desired results [3]. Despite the above advantages, didactic lectures have many drawbacks and many medical schools have shifted a major part of their teaching-learning activity to more student-centric methods. Teaching is not separable from learning and it is not merely providing information or knowledge, but also demonstrating skill, attitudes, and values [4]. The subject of biochemistry involves the teaching of certain facts which cannot be verified practically. It involves memorizing the chemical structure and reactions which may be difficult to imbibe. This makes the student think that the study of biochemistry is volatile, difficult, and uninteresting.

With these drawbacks of didactic lectures, many innovative methods have been introduced to the teaching system like problem-based learning, role play, mind mapping, etc which involve a small group of students and encourage them to make learning more effective, efficient, and meaningful. We need to develop innovative active learning modules both inside and outside of classrooms, which in turn will foster more interaction among students, ignite their eagerness, create significant learning environments, and in turn help in the recall of topics [5,6]. Creating 3D models is one such innovative teaching-learning tool used to some extent across basic medical sciences. A pilot study where 3D anatomy models were used to teach the most complicated areas of the body like the mediastinum, the upper abdomen, and the pelvis demonstrated that it helped the students to gain a deeper understanding of the shape and spatial organization of the anatomical structure [7]. Model-making fosters many attributes of active learning like creativity, application of medical knowledge, team building, leadership, resource management, and communication skills. Active learning is a learning activity that engages students actively in a classroom through different methods unlike didactic lectures [8]. Based on all these facts we hypothesized that introducing 3D model-making activity as an innovative method of active learning will help the students to enjoy learning, think differently, understand better, expand their knowledge and recall information more comprehensively.

2. Methods

The study was conducted in the Department of Biochemistry of a Private Medical College recognized by the National Medical Commission to admit 200 students per year for the Bachelor of Medicine and Bachelor of Surgery (MBBS) program. The phase I medical undergraduate students participated in creating 3D models explaining the biochemical concepts during their second semester. A total of 200 students were divided into 20 groups with 10 students in each group as per their university register numbers. Topics in Biochemistry, which were taught during their lecture classes were selected and allotted to each group by lottery method (Table No 1). These topics were chosen by the department faculty in consultation with two external subject experts from the must-know and desirable to know sections of the phase I curriculum to meet their respective specific learning outcomes (SLO). For eg. The SLO for the topic, the "fluid mosaic model" of the cell membrane was "to explain the structure and functions of the cell membrane with a suitable diagram". Likewise, it was ensured that the SLOs of all the allotted topics were met at the end of this activity.

The students were given two weeks to prepare the 3D models and were informed that the assessment will be based on their creative ideas and teamwork during the presentation and discussion. To encourage the students and to ensure their active participation in the activity, suitable rewards for the three best models and their respective group was assured. The group met after their class hours to discuss and build the 3D model assimilating all the ideas from their team members. At the end of the second week, each group submitted their respective 3D models to the department (Fig. 1). Two external and one internal faculty assessed the models based on the criteria shown in Table 1 and marks were allotted accordingly. On the day of the assessment, each group was given 10 min for the presentation and 5 min for discussion. The marks were tabulated and the three groups scoring the highest marks were rewarded on the following day.

Following the assessment and before the announcement of the results, feedback was collected from the students on a five-point Likert scale (Table 2). Students were informed that their opinion on the feedback would be voluntary and kept anonymous, with no impact on their academic records. The responses were reported in a summative form. The coefficient of reliability of questions administered was assessed by calculating Cronbach's alpha. The models were exhibited and made available to all

Fig. 1. Shows the selected models prepared by the students with their innovative ideas.

Table 1. List of topics for Model-Making and Assessment checklist used by the evaluators.

Topics for Model Making	Creativity (Marks 20)	Content of the presentation (Marks 20)	Organization of the content (Marks 20)	Involvement of the team members in the presentation (Marks 20)	Discussion and Ability to answer the questions (Marks 20)
1. Fluid mosaic model					
2. Secondary active transport of glucose					
3. DNA structure					
4. Replication fork					
5. Mechanism of enzyme action					
6. Metabolism and biochemical functions of vitamin D					
7. Immunoglobulin's					
8. Bilirubin metabolism					
9. Structure of ATP synthase					
10. Transport of dietary lipids by chylomicrons					
11. Glucose alanine cycle					
12. Source of nitrogen and carbon atoms of purine and pyrimidine ring					
13. Metabolism in the fed state					
14. Metabolism in the fasting state					
15. Types ELISA					
16. Rickets					
17. Scurvy					
18. Electrophoresis					
19. Obesity and its complications					
20. In vivo and ex vivo gene editing					

Table 2. Feedback form collected from the students on a five-point Likert scale.

Feedback form

1. Do you feel that model-making is an innovative method of learning in the medical profession?

Yes No

1.1. If 'Yes' to Q.1. then why? 1.2. If 'No' to Q.1. then why?

Questions	Strongly agree (5)	Agree (4)	Cannot comment (3)	Disagree (2)	Strongly disagree (1)
2. Were the topics allotted relevant to your syllabus?					
3. Was sufficient time given for the making of the model?					
4. Was there active participation among all the members of the team?					
5. Do you think this exercise helped you in better understanding the topic?					
6. Did this exercise inculcate the culture of active learning?					
7. Do you think this exercise should be continued?					
8. Do you think more topics can be allotted for model making?					
9. This topic was better understood during the model making exercise					
10. This topic was better understood during didactic lectures					
11. Model making exercise enhanced my creativity and application of knowledge in biochemistry					
12. Were you able to easily find the resources for model making?					

students for visualizing and discussing among themselves to clear their concepts.

Statistical analysis: Data was tabulated in Microsoft excel and responses of the students to the feedback questionnaire were represented as percentages. Cronbach's alpha of the questions administered had high internal consistency with a score of 0.86.

3. Results

About 92% of the students expressed that creating 3D models was an innovative method of learning in the medical profession, 96.3% agreed that the topics allotted to the entire batch were relevant to their syllabus, and 81.6% agreed that sufficient time was given for creating the 3D model. Around 63.8% agreed that there was active participation among all the members of the team, however, 20.9% of students were neutral, and 15.3% of students disagreed. About 84% agreed that this exercise helped in a better understanding of the topics, 87.5% agreed that this exercise inculcated the culture of active learning, 69.9% strongly agreed that this exercise should be continued, 77.2% agreed that more topics should be allotted for model-making, 85% agreed that 3D model-making activity enhanced their creativity and application of knowledge in biochemistry, 74.1% agreed that they could easily find the resources for creating the 3D model, and 87% agreed that the topic was better understood during the making of the model. 60% strongly disagreed and 27% disagreed that the topic was better understood during didactic lectures (Fig. 2).

4. Discussion

Education should inculcate self-discipline and commitment to achieve in the minds of students and it should be filled with fun and thrill, rather than burden and boredom. Learning empowers students with scientific understanding, precision skills, and a positive attitude guiding the student in the right direction. This is the foundation that justifies the concept of "Learning by Doing" such as creating a 3D model to understand a particular topic scrupulously. Even with the best teaching modules, there are possibilities of some disconnect between the

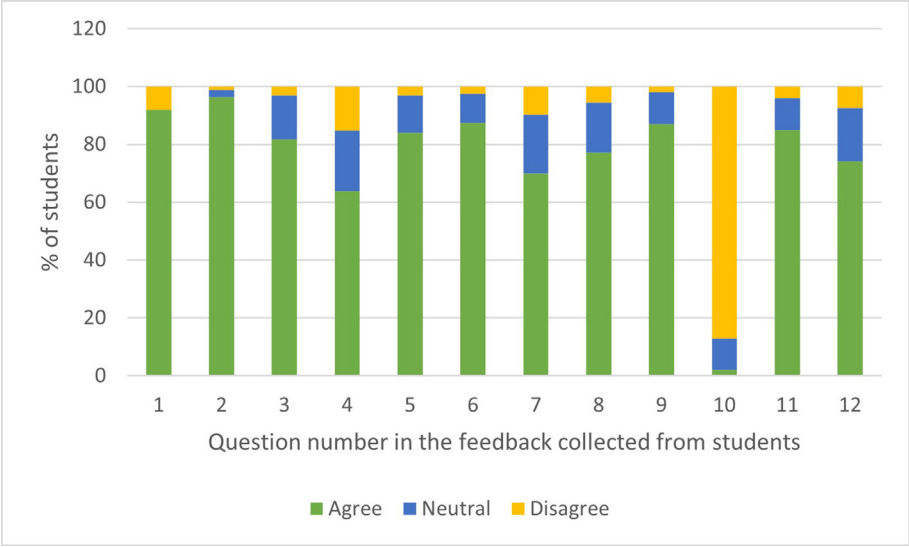

Fig. 2. Shows the student responses to the questions included in the feedback form collected on a five-point Likert scale.

instructional teaching and the performance score which often leads to misinterpretation about the student.

Teaching with the help of 3D models is now taking a step forward in undergraduate medical education and this approach is also accepted by clinicians for diagnosing and treating patients [9]. The current 2-Dimensional teaching method, like didactic lectures using PowerPoint presentations, is insufficient to make the students understand the subject meticulously. To make the subject interesting and enjoyable we employed this innovative method of making 3D models for different topics in the syllabus. Evaluation is an integral part of medical education and feedback from the students is the most common evaluation method used [10]. To assess the effectiveness of this active learning method, feedback was collected from all the students on a five-point Likert scale.

On the day of the presentation, students were well prepared and enthusiastic to present their models created with their innovative ideas. The topic of rickets was presented and explained through a puppet show which depicted how a normally born child develops the clinical features of rickets due to deficiency of vitamin D resulting from inadequate exposure to sunlight and cultural activities, later recovered completely with prompt supplementation with Vitamin D. The sources of carbon and nitrogen atoms in the ring structure of purine and pyrimidine was depicted in the form of a golf course wherein the golfer strikes the differently colored balls to their respective positions.

The phase I medical undergraduate students expressed that creating a 3D model was an innovative method of learning in the medical profession as it helped to understand the topics comprehensively, brought out the creativity in their minds, enhanced confidence, was a stress buster, helped to recollect the topics with ease, inculcated the spirit of teamwork and helped to think out of the box. Almost all the students agreed that the topics allotted were relevant to the syllabus which helped them to gather more information about the subject. About three-quarters of the students agreed that sufficient time was given to create the model during which they could plan, procure the required materials, and build the model. Most of the students agreed that model-making exercise enhanced their creativity and application of knowledge in learning biochemistry. More than half of the students agreed that there was active participation among all the members of the team, unfortunately, the rest of the students did not agree with this. The majority of the students agreed that this exercise helped them to better understand the topic which inculcated the culture of active learning, agreed that this exercise should be continued and more topics must be allotted for model-making so that they can understand each topic in detail. They also agreed that they could easily find the resources to create the model. Overall, the students understood the topic better during the making of the model when compared to the explanation of the same topic during the didactic lecture. Barling et al. in a similar exercise demonstrated that students were highly resourceful in creating the models which stimulated, informed, and educated the constructors. These models were later used as a teaching resource in didactic lectures [11].

Despite obtaining positive feedback from a majority of the students, a small percentage of students did make the following remarks: Some of the students opined that the model-making exercise was time-consuming and suggested that it could be organized at the end of the first semester. A few of the students mentioned that only one single topic could be studied in detail and not everyone in the team participated or contributed to the planning and building of the model, some of the students desired freedom in choosing the topic for model-making which was not given during this instance.

To make this activity more acceptable to the students we considered addressing a few of the remarks or suggestions given by the students. For example, this activity can be planned during the first semester, the presentation of the model can be made in front of all the students so that everyone understands it better and freedom to choose the topics may be given to the students ensuring that there is no repetition of the topics.

Keeping in mind the drawbacks of didactic lecture, which is the mode of teaching followed by most medical schools in India, NMC has introduced a competency-based curriculum, which describes the attributes the medical undergraduate should possess at the end of the course. This is achieved by shorter group discussions, inter-departmental integration in the medical school, the introduction of objective structured practical examinations (OSPE) and objective structured clinical examinations (OSCE), etc. With the results of the current study, the model-making activity may be introduced as one of the components of the new NMC curriculum. Similar studies may be carried out in other medical schools and the effectiveness of model-making as one of the teaching-learning methodologies can be further validated.

Conflict of interest

The authors state that there is no conflict of interest.

References

[1] Agarwal AK. Medical council of India. Natl Med J India 2018; 9:50.
[2] Gupta S, Parekh UN, Ganjiwale JD. Student's perception about innovative teaching learning practices in Forensic Medicine. J Forensic Leg Med 2017;52:137–42. https://doi.org/10.1016/j.jflm.2017.09.007.
[3] Kaufman DM. ABC of learning and teaching in medicine: applying educational theory in practice. Br Med J 2003;326: 213–6. https://doi.org/10.1136/bmj.326.7382.213.
[4] Dee Fink L. Creating significant learning experiences: an integrated approach to designing College courses, revised and updated. Wiley; 2013.
[5] Parimala K, Subash KR, Jagan N, Vijay Kumar S, Viswanathan SCM. Assessment of pharmacology teaching-A critical appraisal by medical school learners. Int J Med Res Health Sci 2013;2:1–6.
[6] Joshi A, Ganjiwale J. Evaluation of students' perceptions towards an innovative teaching-learning method during pharmacology revision classes: autobiography of drugs. J Clin Diagn Res 2015;9:FC01–4. https://doi.org/10.7860/JCDR/2015/12775.6153.
[7] Pujol S, Baldwin M, Nassiri J, Kikinis R, Shaffer K. Using 3D modeling techniques to enhance teaching of difficult anatomical concepts. Acad Radiol 2016;23:507–16. https://doi.org/10.1016/J.ACRA.2015.12.012.
[8] Marks SC. The role of three-dimensional information in health care and medical education: the implications for anatomy and dissection. Clin Anat 2000;13:448–52. https://doi.org/10.1002/1098-2353(2000)13:6<448::AID-CA10>3.0.CO;2-U.
[9] Traynor G, Iu Shearn A, Milano EG, Ordonez MV, Nieves M, Forte V, et al. The use of 3D-printed models in patient communication: a scoping review. J 3D Print Med 2022;6: 13–23. https://doi.org/10.2217/3DP-2021-0021.
[10] Husain M, Khan S. Students' feedback: an effective tool in teachers' evaluation system. Int J Appl Basic Med Res 2016;6: 178–81. https://doi.org/10.4103/2229-516x.186969.
[11] Barling PM, Ramasamy P. Model construction by students within an integrated medical curriculum. Clin Teach 2011;8:37–42. https://doi.org/10.1111/J.1743-498X.2010.00419.X.