

Exploring Physiology Through Working Model Preparation by Undergraduate Students

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Background: Physiology is a foundation for studying medicine. Student-centred learning methods are needed for a better understanding of the subject. Preparation of working models by students in Physiology is expected to provide better understanding of the subject since they learn by doing these themselves. The present study was designed to understand the effectiveness of a working model making activity for first-year undergraduate medical students.

Methods: The participants were 97 first-year medical undergraduate students. These students were divided into teams. The topics to prepare working models were chosen by the students according to their interests. The models were prepared by using clay, thermocol, batteries, motors, etc. by the students. These models were displayed in an exhibition organized by the department and marks were awarded to the students according to their performance. A feedback questionnaire form was provided to the students, which they had to complete individually. The questionnaires were analyzed to understand the perception of students regarding the activity.

Results: Of the students, 35% strongly agreed and 52% agreed that model making was a useful exercise and helped them in understanding Physiology. Of the students, 27% strongly agreed and 50% agreed that their understanding improved with this assignment and 32% of students strongly agreed and 58% agreed that this activity allowed them to analyze the topic and think logically. Of the students, 36% strongly agreed and 50% agreed that they gained confidence in the topic while they were preparing the model and seeing it functioning. Of the students, 37% strongly agreed and 46% agreed that they had the opportunity to work in a team. Of the students, 39% strongly agreed and 47% agreed that faculty had supported them appropriately. Most of the students agreed that they would recommend such activities to their friends studying in medical colleges elsewhere.

Conclusion: The students found the activity not only interesting but useful and would encourage their friends studying elsewhere to participate in such activities.

Keywords: working models, learning by doing, concept developing, bloom's taxonomy, team activity

Introduction

Physiology is a fundamental subject forming the basis of medicine and is an integral part of the undergraduate medical curriculum in medical colleges in India. At present, Physiology is taught by different teaching methods which include conventional didactic lectures along with tutorials, small group discussions, and practical/demonstration in medical colleges across the country.

John Dewey, an influential educationist in the 20th century, stated "The methodology of teaching leads to the purpose of teaching".¹⁻³ Although Dewey proposed the

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concept for pedagogical teaching and curriculum, the same is applicable in medical education.

The present generation of medical undergraduate students is well informed and aware of various teaching technologies. This may be attributed to easy access to information through the internet. As a result, it is pertinent to understand the requirement of these students and implement a student-friendly teaching-learning method whereby they imbibe concepts and skills taught to them and implement the same for patient management and care. This is best when they analyze the concepts and discover them by doing things themselves. According to Bloom's taxonomy, learning by doing reaches higher-order learning in the cognitive domain because the student can analyze and perform what he/she has learned in class.^{4,5}

Medical education may be considered an important milestone in the progression of a society. The young students who seek admission in different medical colleges across the country are vibrant and their thought processes are highly innovative. Their ideas can be streamlined to develop and evolve their understanding of concepts better.⁶ If we review the curriculum followed in other professional specialities of higher education like architecture and engineering we can appreciate that the curriculum is crafted and designed such that students develop the best of their psychomotor and cognitive skills to understand and implement concepts. One of the teaching and learning methods is the preparation of models in different semesters.⁷⁻⁹ For example, studies are reporting the use of Lego to prepare models by engineering students⁷ and construction of scale model of house assignments were taken up by construction technology students.¹⁰ Kolb and Lemons et al emphasized the benefits of developing knowledge by experimenting during the preparation of model.^{7,11}

Working model preparation ensures that the student can understand the concept.¹² Various advantages in this type of learning would be that the learners can develop the best knowledge, they can develop a scientific attitude with prolonged retention of concept which improves their confidence. The learner feels more responsible since the success of such activity depends on the learner's participation. However, there are many limitations. For example, the teacher must be motivating and enthusiastic about this method. It is a time-consuming method and individual topics are covered rather than the whole system. The students need to spend some resources making models on their own. The success of this method depends on the individual skills of both the learner and teacher.

Model making activity is usually not a part of the undergraduate medical curriculum in India and to the best of our knowledge, is not practised elsewhere in any other medical college in the country. Considering these facts, the first-year undergraduate medical students in the institute were allotted an assignment to prepare working models in Physiology. The activity was allotted to medical students in our department to inculcate a scientific attitude in students and develop their cognitive and psychomotor domains. It was further expected that the students had to prepare working models, which meant that their models had to be three-dimensional, functional and not just merely a static replica of organs/tissues.

Moreover, it was important for us to understand the perceptions of the students during the working model making assignments in the department and decide to incorporate the same in first-year undergraduate medical curriculum in the institute. Hence, the present study was conducted to understand student's perspectives on working model preparation assignments in existing first-year Physiology curriculum.

Methods

The present study was exempted from ethical review as per the decision of the Institutional Ethical Committee of All India Institute of Medical Sciences, Rishikesh (ECR/736/Inst/UK/2015).

Ninety-seven students studying in first-year MBBS (Batch 2017–18) voluntarily participated in the present study. We explained the study and written informed consent was obtained. Students were divided equally into 10 teams and asked to discuss within their respective groups and decide a topic in Physiology so that they could prepare a working model. Every team had a team representative. Thereafter, every team representative or the team members were asked to consult with the faculty in the department and discuss the topic of their choice for model preparation. Each of the teams had to prepare models on different topics in Physiology within a stipulated time of 2 months. Students were allowed to discuss and clarify their doubts with the faculty of the department as and when required ([Appendix A](#)). During interaction with faculty, all the groups had equal opportunity to discuss with every faculty.

The students used plastic bottles, battery-operated motors, lights, cellophane sheets, tissue papers, plasticine, clay, coloured balls, and thermocol sheets to prepare their

working models on different topics such as reproductive cycle, dialysis, refractive errors, mechanisms of hearing, sensory and motor pathways, angioplasty, etc. The 3D models were working models. For example, the group which prepared a model showing excitation-contraction coupling in skeletal muscles, used small balls to represent calcium ions and when these balls came in contact with a tropomyosin-troponin complex 3D model, the 3D design showing actin and myosin filaments starting to move towards each other. Other topics are shown in [Table 1](#). After completing the models, students were asked to submit them to the department. All the students who gave consent to participate in the study were provided with a feedback questionnaire form on a Likert type scale for an anonymous survey ([Appendix B](#)).

Table 1 Working Model Topics and What the Students Learned While Developing the Models

S.No.	Topics on Which Models Were Prepared	What Did the Students Learn?
1	Female reproductive cycle	Role of different hormones and how they work in different parts of cycle
2	Tactile pathway	Receptor to cortical level of processing
3	Synaptic transmission	Events involved and how an altered mechanism can affect the transmission in different clinical conditions
4	Dialysis	Principle involved and how it is done in clinical set up
5	Refractory errors of eye	Principles and how correction of errors is done in clinical set up
6	Mechanism of hearing	Receptor to cortical level processing and types of deafness
7	Excitation-contraction coupling in skeletal muscles	Events involved in the process and how it is altered in diseased state
8	Angioplasty	Mechanism and role in different diseased states
9	Arterial and venous circulation	Principles and how it is affected in diseased state
10	Corticospinal tract	Cortical to effector organ processing and different disease states

They had to complete the questionnaire form individually and submit in the department.

An exhibition was organized in the department to judge the models and motivate the students and the exhibition was opened for faculty and students of other departments of the institute. Models were judged by three senior faculty members who were subject experts ([Appendix C](#)). Marks were allotted based on model-making skills, ability to explain the principles involved in models, ability to provide logical answers to the questions raised by the judges on their models, neatness, etc. Each of the team members had to participate actively during the interaction with the judges. Ranking of the teams was decided after aggregating and averaging the marks allotted by the judges individually. The teams were awarded certificates for their participation in the activity ([Appendix D](#)).

Statistical Analysis

A self-developed questionnaire survey using Likert scale (response scale 1–5) was used in the present study (5 – Strongly agree; 4 – Agree; 3 – Neutral; 2 – Disagree; 1 – Strongly disagree). Descriptive statistics like median, Interquartile range were used to analyze the responses. Data were analyzed using MS Excel 2010 for windows.

Results

[Table 1](#) represents the details of working model topics and what the students learned while developing the models.

Based on the analysis of questionnaire forms, the following observations were made ([Figure 1](#)): 35% of the students strongly agreed and 52% agreed that model making was a useful exercise and helped them in understanding Physiology better. Twenty-seven percent strongly agreed and 50% agreed that their concepts improved and 32% strongly agreed and 58% of students agreed that this activity allowed them to analyze the topic in a logical manner. Of the students, 36% strongly agreed and 50% agreed they gained confidence in the topic while they were preparing the model and seeing it functioning. Thirty-seven percent strongly agreed and 46% agreed that they had the opportunity to work in a team. Thirty-nine percent strongly agreed and 47% agreed that faculty had supported them appropriately whenever they required and have guided them in model preparation. However, only 30% of the students strongly agreed and 32% agreed that all the group members actively participated. Nineteen percent of students strongly agreed and 40% agreed that they wanted to have more model making activities. Of the students 32% strongly agreed and 46% agreed that they would recommend

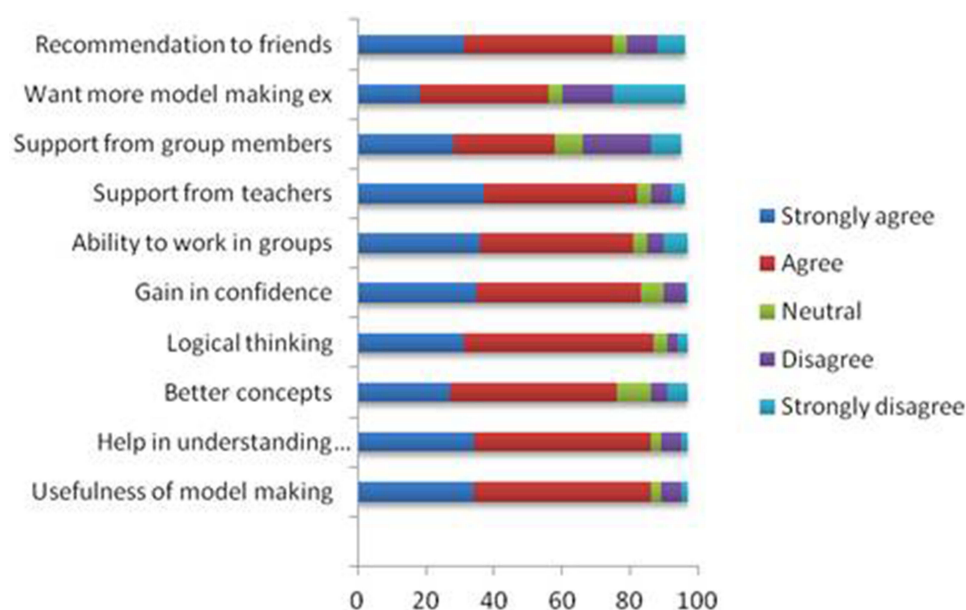


Figure 1 Bar diagram to represent the result of the anonymous feedback survey from students.

such activities to their friends studying in medical colleges elsewhere in the country (Table 2).

Discussion

Medical education in the present scenario is based on student-centric concepts. The traditional teaching methods where teaching was mostly in the form of didactic lectures and there was hardly any emphasis on the analytical approach, the present-day medical curriculum is based on problem-oriented study.¹³ The present generation of tech-savvy adolescents have a scientific attitude; therefore, they

need a conceptual approach rather than rote learning. Medical education in India is in a transitional state where it is essential to follow a student-centric approach to teaching. The students are encouraged to develop analytical skills and focus on applied aspects with teachers acting as facilitators.¹⁴

A working model making competition was organized to assess students' ability to understand Physiology topics and demonstrate their analytical skills in developing a concept. The students were given the freedom to choose the topics and to read about them from whatever source they found relevant. They could refer to any book, journal, webpages, youtube, or animations to search in detail for preparing their

Table 2 Responses of Students (n=97) Expressed as Percentage

Parameters	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Median	IQR	Mean	SD	Mode
Usefulness of model making	35.1	53.6	3.1	6.2	2.1	4	1	4.1	0.89	4
Help in understanding Physiology	35.1	53.6	3.1	6.2	2.1	4	1	4.1	0.89	4
Better concepts	27.8	50.5	10.3	5.2	6.2	4	1	3.89	1.06	4
Logical thinking	32.0	57.7	4.1	3.1	3.1	4	1	4.1	0.87	4
Gain in confidence	36.1	49.5	7.2	6.2	1.0	4	1	4.13	0.87	4
Ability to work in groups	37.1	46.4	4.1	5.2	7.2	4	1	4	1.13	4
Support from teachers	38.5	46.9	4.2	6.3	4.2	4	1	4.08	1.02	4
Support from group members	29.5	31.6	8.4	21.1	9.5	4	3	3.5	1.34	4
Want more model making assignments	18.8	39.6	4.2	15.6	21.9	4	2	3.18	1.47	4
Recommendation to friends	32.3	45.8	4.2	9.4	8.3	4	1	3.83	1.21	4

Abbreviations: IQR, interquartile range; SD, standard deviation.

models. The students were allowed to consult their friends or siblings studying in engineering or other professional courses, to understand the use of different methods and technologies to prepare their functioning models.

The model making task was allotted since they could learn by doing themselves. This included identifying a topic of their interest, studying it in-depth, collecting material, searching for references, discussion with team members and finally preparing the working model on the basis of learned principle which made them use their analytical skills, motor skills, communication skills, and creativity. The students were highly motivated and had a spirit of competition to receive certificates and prizes for their participation and final performance. Working models were prepared using simple materials that reflected the creativity of the students (Figure 2). They made considerable efforts to understand the topic, and they could also answer the questions raised by the judges in a very logical way. Analytical skills of the students were tested by judges who asked various clinical scenarios based and problem-based questions, which were answered by the students satisfactorily. Moreover, faculty from other departments of the institute appreciated students' efforts and logical understanding of the topics and credited the department for organizing such an event.

Feedback in the form of an anonymous survey was obtained from these students. The feedback from the students gave the authors some very useful and relevant information. Since the model making assignment was a part of the

curriculum followed in the institute to promote higher-order thinking in students, understanding the viewpoint of the students was relevant, so that changes in the activity could be made accordingly for forthcoming batches.

Most students had a positive attitude towards the assignment and they agreed that it was useful in understanding Physiology. The activity provided them with the ability to analyze and develop a better conceptual understanding of Physiology. They enjoyed the activity and gained confidence in the topic. They could learn better by doing things themselves which involved an intricate analysis of the topic and hence they retained concepts. In the entire process of searching different resources, they were able to explore wider aspects of the topics. They agreed that they would recommend their friends studying in other medical colleges in different parts of the country to discuss it with their teachers to conduct such activities in their colleges.

Students had the opportunity to work as a team with specific aims and objectives throughout the activity. The team leader would allocate the team members with different tasks: members had to prepare the design of the model, some would work on making it functional. Some members were involved in colouring and providing an artistic finish to the models, some prepared supportive charts or pictures for their models. Every member of the team had to study their respective topics and discuss them thereafter with each other. The entire activity promoted good communication skills and respect among team members, which is needed in team-based learning. Their team effort was

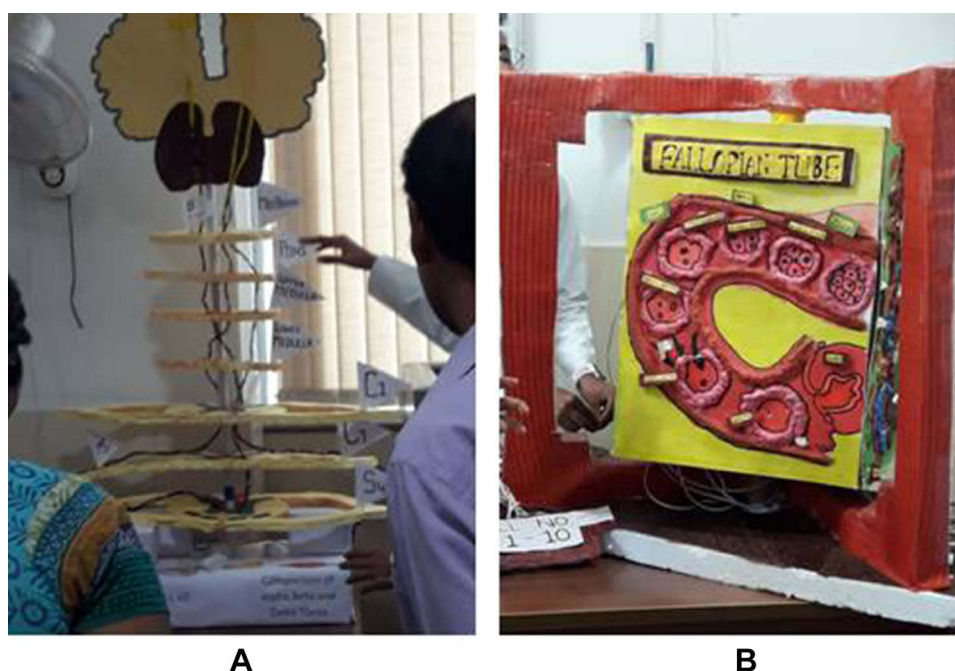


Figure 2 Working Physiology models prepared by students in the exhibition conducted by the Department (A and B).

reflected in their outcomes as well. However, working together in a group needed some more guidance from the faculty so that better team spirit could be developed as there were instances of disagreement among the group members during the initial phase of the activity.

The long duration of 2 months was another limitation to this activity. Further, the students had to be constantly asked about their progress of model preparation and then motivated by the faculty. Sometimes the student's initiative was lacking. This could have been due to their involvement in other subjects, time constraints or discouragement by other team members. In the present study, no pre-test and post-test was done. Since this kind of activity was not a part of the routine curriculum in Physiology, our focus was to initially organize and analyze the activity and obtain student's feedback, so that changes could be made in it for future groups. Despite a few limitations, students took an interest in the activity and gave creditable performance.

Further, we realize that to conduct such activity, dedicated teamwork and motivation are needed. Equal participation and encouragement by team members and leadership of team representatives played a pivotal role in the success of the activity. As teachers, we could assess that the assignment gave them an impetus to think and search beyond their limitations and challenge their motor and cognitive domains without monotony, which could have been difficult in didactic lectures or simply from reading books.

Acknowledgment

Figures depicting the models have been presented after obtaining written informed consent from the participants.

Disclosure

The authors report no conflicts of interest in this work.

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