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Research Article

USE OF 3-D MODEL FOR BETTER UNDERSTANDING AND LONG-TERM RETENTION OF MOLECULAR DETAILS OF THE DNA STRUCTURE

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A R T I C L E I N F O

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A B S T R A C T

Introduction: 3-D structures and biochemical transformations at molecular level are difficult to simulate. The available DNA models are either highly complex to be routinely used for teaching or depict the salient features at the gross level only.

Objective:
1) To introduce 3 -D model for teaching DNA structure
2) To compare the use of 3-Dimensional Model and conventional PPT techniques for long term recall of the DNA structure at the atomic level

Methodology: DNA model was prepared from easily available materials like beads, wire etc., having the potential of being routinely used to study the complex 3-Dimensional DNA structure to a dimension at the atomic level. The DNA structure was taught to 141 1st MBBS students divided into 2 groups, using DNA model and PPT respectively. Pre-post and recall test after 3 months were conducted followed by crossover and feedback.

Results: 78% students found teaching using model better. Highly significant difference (p=0.000) was observed between Pre and Post test scores in the 2 groups. There was no significant difference between the 2 groups in the Pre test (p=0.592) and Post test scores (p=0.282) respectively. However significant difference (p=0.048) was observed in the Recall test scores with those taught using DNA Model performing better.

Conclusion: The use of different teaching aids did not affect the learning of the students on short term basis. As compared to PPT, DNA model having 3-D visualisation generated greater interest leading to better long term recall.

INTRODUCTION

Health care courses and curriculum necessitate remembering and memorizing innumerable facts besides developing the skill and aptitude to incorporate and recollect the concepts about the topics. Visual and kinaesthetic learning helps students comprehend difficult subjects better (3, 7). Biochemistry is the key pivotal subject which lays the foundation for a better understanding of other basic and clinical subjects of the medical curriculum. Biochemistry essentially deals with understanding the three dimensional structure, functions and biochemical transformations under gone by various micro and macro bio-molecules. Understanding of the subject of Biochemistry essentially depends on the perception of the students as it is difficult to simulate biochemical processes at molecular level. Traditional classroom teaching lacks effective teaching and learning aids which lead to a better appreciation of the complex 3-Dimensional structure of bio-molecules of physiological significance. Traditional teaching methods routinely used lead to learning, however, it is hoped that teaching with the aid of models may lead to a better learning with understanding (9, 6).

Various models of the DNA are available in the world, which can be used to explain the complex 3-Dimensional structure of the DNA to the undergraduate students. The models which correctly depict the 3-Dimensional structure of DNA at atomic/molecular level are not only highly complex but also very expensive and cannot be routinely used for classroom teaching. The other DNA Models which are relatively much cheaper and are routinely employed by various institutions for undergraduate teaching depict the salient features of DNA at the gross level only hence not suitable for usage at the Graduate/ Post-graduate levels.

A need was felt to develop a DNA model (using low-cost and easily available materials) which clearly shows the 3-Dimensional structure of DNA at the atomic level to a dimension. A DNA model prepared from easily available materials (e.g. Beads of different colours and sizes, steel wire

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etc.) which clearly depicts to dimension all the features of the 3-dimentional structure of the DNA at the atomic level and

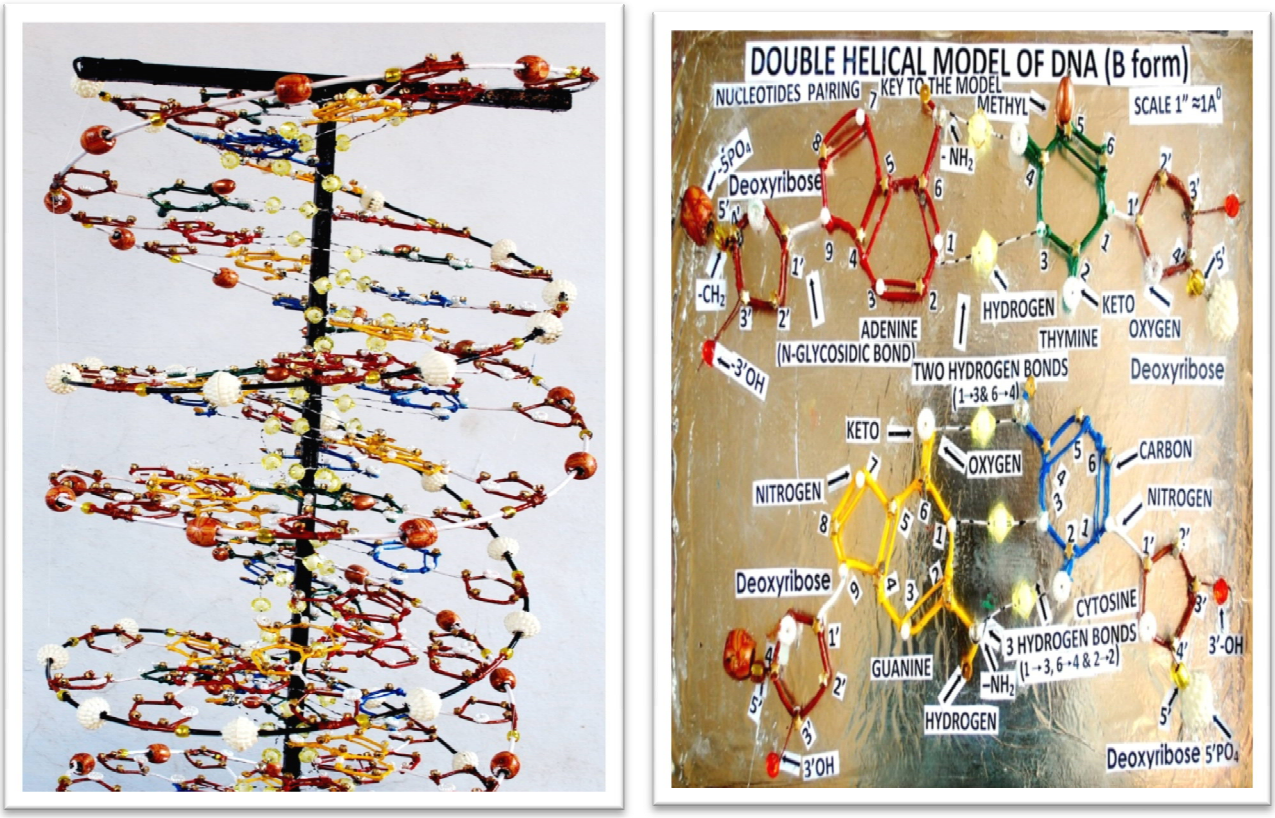


Fig 1 Simple DNA Model for teaching structural details at the Molecular Level

has the potential to be routinely used at both the undergraduate and post-graduate levels to understand and remember all the features of the complex 3-Dimensional DNA structure at the atomic level was employed in the present studies (2, 4).

Aims and Objectives

1. Develop a simple inexpensive DNA model having the potentials to be routinely used in the class room to explain all the aspects of the 3- Dimension of DNA at atomic level along with all its properties to a dimension.
2. To compare the use of 3-Dimensional Model and conventional PPT techniques to understand and remember over a longer period the basic features of the DNA structure at the atomic level

METHODOLOGY

The study was conducted in the Department of Biochemistry, Himalayan Institute of Medical Sciences, Swami Ram Nagar, Dehradun after obtaining approval from the Institutional Research and Ethical committees. Out of 150 students admitted in 1st MBBS 2015 batch, 141 students who participated in the study were divided into 2 groups of 71and 70 students respectively. Pre test **(MCQs and SAQs)** was conducted for both the groups to assess the understanding of the students and also to ensure that there was no selection bias. Group1 was taught the structure of DNA using the DNA model prepared indigenously keeping in mind the needs and requirements of the medical students. The Model is simple yet shows all the salient features of the DNA which an undergraduate student is required to know to have a better and clear understanding of the subject (Fig. 1). The group 2 students were taught using Power Point Presentation as a teaching aid. The content of both the lectures was same and taught by the same teacher to avoid bias.

Post test **(MCQ and SAQs same as pretest)** was conducted after the 1st teaching session, for both the groups to assess the learning and understanding of the students. Feedback was obtained using Likart scale from students and faculty.

Test of recall **(Puzzle and SAQs)** was conducted after 3 months, just before the start of Molecular Biology lectures, to assess the recall on the topic taught to the groups using the 2 different teaching aids.After collection of pre-, post test and recall test data, the students of the 2 groups were exposed to the teaching aid other than the one they were previously exposed to and feedback was taken from them.

The faculty and post graduate students of the department were invited as observers for the sessions and provided their feedback on the sessions.

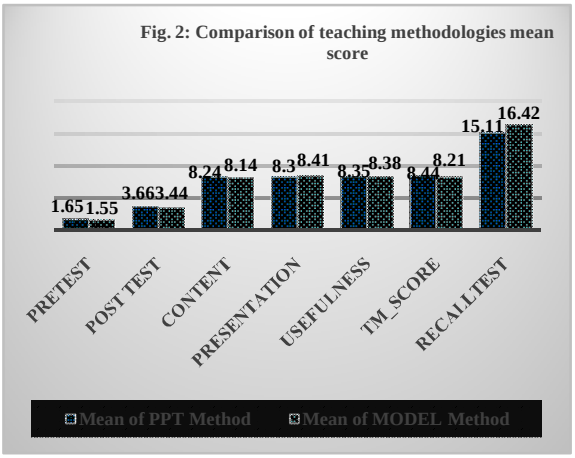
Evaluation of the use and effectiveness of the teaching methodology was done by feedback obtained both from the MBBS students and the faculty in the department using Likert scale, after the 1st and crossover sessions. Feedback was also used to explore the areas of improvement for better teaching and learning (1, 5). Data was analysed using SPSS version 22 and results were obtained.

RESULTS

- In the Ist Session total 141 students participated in the study. They were divided into two groups, one was

taught using PPT (70 students) and other by DNA model (71 students) as a teaching aid. Pre- and post test and feedback on Likert scale was taken from both the groups.

- There was a highly significant difference (p=0.000) observed between Pretest and Post test scores of the students in both the groups.
- No significant differences (p=0.592) were observed in the Pretest scores between the 2 groups indicating that there was no selection bias.
- No significant difference (0.282) was observed in Post test scores of the student between the 2 groups suggesting that the use of different teaching aids did not lead to any significant difference in the learning of the students on short term basis.



- Significant difference (p=0.048) was observed in the Recall test scores of the students when taught using model as over using PPT as TL aid indicating that the use of Model as a teaching aid led to better learning and recall on long term basis (3 months)
- In the 2nd crossover session after the recall test 138 students responded and gave their feedback on Likert scale
- 81% faculty felt that use of 3-D model for teaching arouse the interest in front and back bencher equally and 87.5% felt that it is feasible to use models as teaching aid for regular teaching.
- Suggestions as given by faculty on other topics which can be taught using models include: Replication, transcription, translation, structural organization of proteins, structure of Haemoglobin, lipoproteins structure, biologic oxidation, chemistry of nucleic acids and carbohydrates.

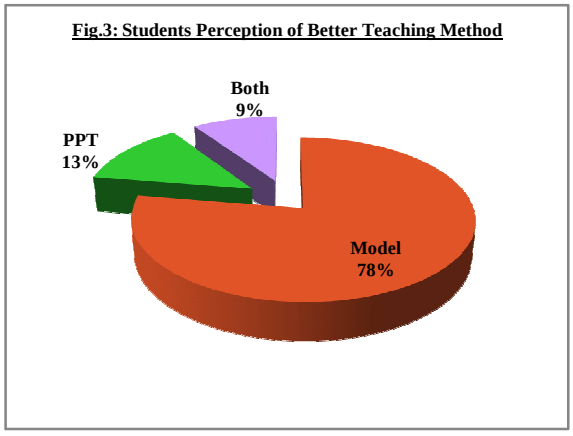


Table 1 PPT as Teaching Aid- Student perception

S.No	Advantage	Frequency (%)	Disadvantage	Frequency (%)
1	Better Understanding	35 (24.8)	Lack of 3 D view	10(7.1)
2	Easy to take notes/ theoretical knowledge	33 (23.4)	Less Understanding	27(19.1)
3	Diagrams helps	6 (4.3)	Problem with recall	3(2.1)
4	Better visualization	6(4.3)	Lack of concentration	7(5.0)
5	saves time	5(3.5)	less interactive	2(1.4)
6	Wide content coverage	17(12.1)	No Disadvantage	8(5.7)
7	Misc	11(7.8)	Misc	17(12.1)
8	Not Attempted	28(19.1)	Not Attempted	66(46.8)

Table 2 PPT as Teaching Aid- Student perception

S.No	Advantages	Frequency (%)	Disadvantages	Frequency (%)
1	Better understanding of concepts	65 (46.1)	Cannot see from Distance	15 (9.9)
2	3 D Visualization	40(28.4)	Can not takes notes	5 (3.5)
3	Interactive & interesting	6(4.3)	Not all topics can be covered by models	9 (6.4)
4	Better recall	9(6.4)	No Disadvantage	24 (17.0)
5	No Advantage	2(1.4)	Miscellaneous	7 (5.0)
6	NA	19(13.5)	NA	79 (56.0)

DISCUSSION

A comparative study was conducted on the usefulness of PPT and 3-D Model of DNA for understanding and retention of various features of the DNA structure. A pre test conducted before the start of teaching revealed that no significant difference occurred between the 2 groups which meant that the students of the 2 groups had almost identical knowledge and understanding of the salient features of the DNA structure.

Based on the present studies following observations were made

1. Both the methods led to better understanding of the salient features of the DNA structure as a highly significant difference was observed between Pre test and Post test scores of the students in both the groups.
2. When the post teaching test was conducted immediately after the 1st teaching session, no significant difference occurred between the 2 groups in understanding of the salient features of the DNA structure. In a meta-analysis conducted by PushpaPotaliya *et al* (2015) to assess the overall impact of audio-visual aids in teaching-learning of medical students in India also found in general the learning experience was not significantly dependent on the aids used during sharing knowledge and expertise, though some of the studies showed marginal and tangential benefits while the capacity of the facilitator matters. In a similar study conducted by Jamuna Rani etal (2012) there wasn't a significant difference in the performance of the students when using PPT or 3D model with chalk and board as teaching aids though the use of models was welcome idea as a change from the power point presentation.

3. However when the recall test was conducted after 3 months, the students where 3-D Model was used as a teaching aid showed a much better retention of the salient features of the structure and function of DNA.
4. In a study conducted by Carol Robertson on Understanding the structure of DNA through models and motion, it was observed that the students get the kinaesthetic advantage with use of models for better learning and also have a better understanding of the scale and proportions involved in the structures. Using these activities, students become proficient in knowing the basic structure of DNA.(8)
5. Based on the above observations it can be safely concluded that although on short term basis both the modes of teaching were equally effective in knowing the salient features of the DNA structure however the knowledge obtained by the students through the 3-D model studies was retained on long term basis.
6. Feedback received from 78% of the students and 87.5% faculty was in conformity with the above observations that as compared to use of PPT as a teaching aid, the knowledge obtained with the use of 3-D models was a better mode of teaching and learning because the visualisation of the 3-D structure leads to much better retention. Survey conducted by Carol Robertson show that students believe the activities and models help them learn the structure of DNA. Using body modelling and incorporating DNA chenille stem models to teach DNA structure can provide students with a strong knowledge base that will serve them well as they go on to learn about DNA replication, protein synthesis, and inheritance and variation. (8)

CONCLUSION

It is the man behind the machine who is essentially responsible for the learning experience of the students and not significantly dependent on the aids used during sharing of knowledge and expertise. However teaching aids like models arouse greater interest among students and have visual impact along with the kinaesthetic component which can improve retention.

Recommendations

Models have been the best ways to depict and explain complex biochemical processes in advanced research. Use of 3-D models depicting the various biochemical processes which cannot be seen otherwise can provide 3-D vision to molecular processes besides the kinaesthetic advantage for better understanding and long term retention of the basic concepts thus laying a sound foundation for the understanding of the biochemical basis of the various aspects in the practice of Medicine.

Limitations of model based studies

Following are the possible limitations of the 3-D Model based teaching

1. Preparing 3-D models require lot of hard work and is a highly time consuming phenomenon.
2. 3-D model based teaching may be a very effective tool to study various structural features of biomolecules of importance, however, it may be virtually impossible to cover all the cellular functions using the model based teaching tool.

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