DOI: 10.7860/JCDR/2023/59391.17377

Anatomy Section

Original Article

Role of Handmade Models in Teaching Early Stages of Human Embryology: A Quasi-experimental Study from South Kerala, India

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ABSTRACT

Introduction: Physical models are being used in embryology lectures along with PowerPoint presentations to improve the spatial orientation of students. But the demonstration of the sequence of changes is not possible with commercial models due to nonavailability and high expenses. The latest audio-visual aids including three-dimensional projections like simulation-based screens, or virtual reality enhance the visual-spatial ability of the students but are very costly and not affordable for all institutions.

Aim: To compare the effectiveness of hand-made physical models with the PowerPoint presentation mode of teaching in understanding the 3D concept of embryology, among first-year MBBS students and to assess the students' perception of this model-based teaching.

Materials and Methods: The study was conducted using a quasi-experimental study design, on 218 phase 1 medical students of Government Medical College, Thiruvananthapuram, Kerala, India, from February 2020 to August 2020. The students were divided into two equal groups. Group B was taught the topic "Second week of embryonic life" with a PowerPoint lecture session (n=109) and the Group A had in addition a demonstration with the handmade models (n=109). Pretest and post-test were conducted with an internally validated questionnaire. Feedback on the student's acceptance of teaching/ learning with models were also collected. The improvement of the test scores was analysed using paired t-tests in both the test and control groups.

Results: Statistically significant improvement in knowledge score was obtained while comparing the post-test scores of the intervention group (mean score was 4.83±2) with that of the non intervention group (mean score was 3.99±2.06) (student's t-test, p-value <0.05). It was observed, 99.1% of students were satisfied with this model-assisted teaching, especially with the series of models demonstrating the sequence of events. A 93.1% of students said that they needed such model-assisted lectures in other subjects also.

Conclusion: Series of models pertaining to a particular event is beneficial and effective for learning complex concepts of embryology. Also, it's a long-lasting, innovative mode of teaching which can be done cost-effectively.

Keywords: Anatomy, Cost-effectiveness, Education, Embryology Models

INTRODUCTION

The study of human embryology deals with a highly complex process that transforms a single cell into a fetus in nine lunar months. This involves the amazing integration of a multitude of developmental phenomena. In universities in India, embryology as a subject is taught during the first academic year of the undergraduate MBBS curriculum. Understanding the detailed developmental process forms a strong anatomical basis for comprehending the gross structure and related anomalies [1]. So, it is highly desirable that medical students have sound theoretical knowledge with spatial orientation, regarding different stages of development during intrauterine life.

Attending didactic lectures and referring to standard textbooks of embryology is still the mainstay of learning embryology for a good percentage of medical students [2]. While books and Anatomy atlases provide a two-dimensional orientation of the basic concepts, generally they fail to impart the expected level of understanding [3]. Didactic lectures aided by PowerPoint presentations and charts may serve to impart spatial orientation. Students, on the whole, may find it a challenge to imbibe the concepts delivered during routine lectures with projections of videos. Although the student passively imbibes the information, such lectures may fail to trigger their deeper learning process and improve the learning results [4].

Three-dimensional anatomy models, which the students can hold and manipulate can improve their kinesthetic learning. These physical models will stimulate the students to correlate the three-dimensional orientation of developing structures, thereby reinforcing the concept of that particular stage of development in a way more appreciable. Physical hand-painted embryological models are well appreciated by students and it can not be replaced by digital 3D atlases [2].

Models that are currently being used are made of synthetic fiber, resin or plaster of Paris. Each has its advantages and disadvantages. Every institution's purchase model depends on its economic potential. In government institutions like ours where only limited funds are available, procuring an expensive model limits the purchasing power to a minimum. Cost-effective models that the faculty and students can make with locally available material are a good alternative to overcome these limitations [5]. More models (individual or series) can be made at low cost, thereby allowing the students to learn in small groups or individually. The present study was conducted with such hand-made, cost-effective sequential models as educational tool.

The aim of the present study was to compare the effectiveness of hand-made physical models alongside a PowerPoint presentation in understanding the 3D concept of embryology among phase 1 MBBS students and to assess the student's perception towards using physical models in embryology teaching.

MATERIALS AND METHODS

A quasi-experimental study with pretest and post-test was conducted in the Department of Anatomy, Government Medical college, Thiruvananthapuram, Kerala, India, from February 2020 to August 2020. Approval for the study was obtained from the Institutional Ethics Committee. (HEC.No.01/50/2020/MCT dated 07/02/2020.) Informed consent was obtained from the students after explaining the study procedure.

Inclusion and Exclusion criteria: All phase 1 MBBS students, 2019 batch were included in the study and students who were not willing to study were excluded from the study.

Out of 250 phase 1 MBBS students, 218 students participated in the study. There was no dropout postintervention in any group. The sampling frame used was the attendance roll of the students. Alternate students were enrolled in the group.

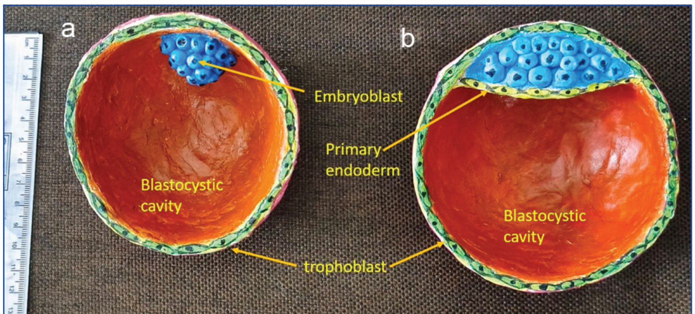
Group A: Intervention group

Group B: Non interventional group.

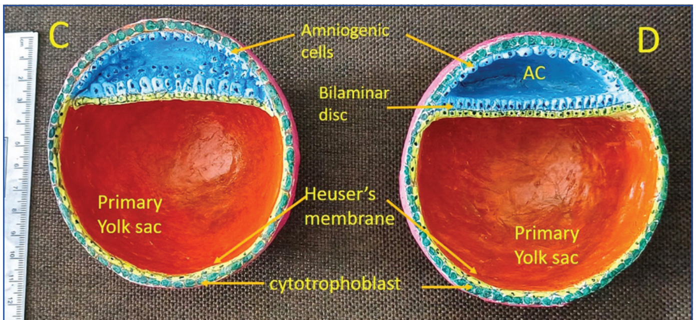
Study Procedure

The authors decided to conduct the study during a general embryology lecture class. The changes in the embryo in the first week of intrauterine life are relatively easy to understand. Since the 3D conformational changes started happening mainly from the 8th to the 14th day, the second week was selected as the lecture topic. Further weeks were not included due to time constraints. Models of the developing embryo in the second week were made in the department of Anatomy with reference to the diagrams in the embryology textbook [6].

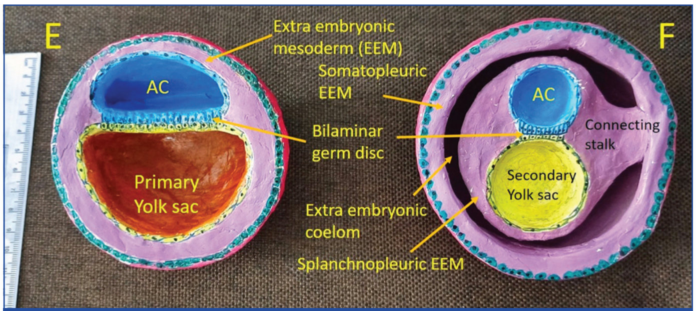
Six coconut shells of appropriate size were cleaned and their outer surfaces were scraped smooth with a knife. A layer of clay was then applied over the outer surface and smoothened. To denote the sequential growth of the embryo, a series of changes were designed in each shell. Cells were made with thermocol balls and fun clay, and the embryonic disc with dried paper pulp mixed with gum and polished with clay. The models were created to impart an accurate spatial orientation regarding the layout of the germ layers, blastocoele, and extra embryonic coelom. The prepared models are shown in [Table/Fig-1-3].



[Table/Fig-1]: Shows, A. Blastocyst with "inner cell mass" (embryoblast), outer trophoblast layer, and blastocystic cavity. B. Single layer of cells on the inner aspect of embryoblast forming primary endoderm or hypoblast.



[Table/Fig-2]: Shows, C. Formation of primordium of the amniotic cavity between amniogenic cells and inner cell mass. Cytotrophoblast is also differentiated. Bilaminar germ disc with amniotic cavity above and yolk sac cavity below.



[Table/Fig-3]: E. Extraembryonic mesoderm formation inner to cytotrophoblast. F. Formation of the extraembryonic coelom, dividing the extraembryonic mesoderm to somatopleuric and splanchnopleuric extraembryonic mesoderm.

A set of 10 embryology questions were prepared, which were internally validated by two senior Anatomy professors in the department. The questions were based on the changes in the embryo and blastocyst during the second week of development. The same set of questions was used for the pretest and post-test. Knowledge score was assessed giving a score of 1 for the correct response and 0 for the wrong response. Total scores ranged from 0 to 10.

Method of Collection of Data

The study was conducted during the routine embryology theory class. A pretest of five minutes duration was done for group B before the lecture class. Then group B (non interventional group) was given the one-hour didactic lecture class, with 3D pictures in PowerPoint presentation and diagrams drawn on the board. After one hour, a post-test was conducted for group B.

Then Group A (interventional group) had the pretest for five minutes. After that, they had the same lecture experience for one hour as Group B, added with models pertaining to the second week of development. The six small handy models were presented and explained to the students. They were allowed to handle them to get a better three-dimensional orientation. After one hour, a post-test was conducted for group A.

Both lectures were handled by the same lecturer to avoid bias. After the post-test, the models were demonstrated to group B students also for the sake of completion of delivery of academic material.

After the sessions, separate time (10 minutes) was allotted for collecting feedback from the 218 students about the simulation we used, by a questionnaire that included 10 closed-ended questions. The responses were recorded on 5-point Likert scale. A structured questionnaire similar to that by Chaudhary P et al., was adopted for collecting the responses about the current intervention [7]. For the present study, a few modifications were made to the questions making them suitable for assessing the student's attitudes toward model-assisted learning. The reliability of the questionnaire showed Cronbach's Alpha value of 0.615. The questionnaire also included one open-ended question asking for their independent observations and suggestions.

STATISTICAL ANALYSIS

The data collected were analysed statistically using Statistical Package for Social Sciences (SPSS) software, version 22.0. The scores of preintervention and postintervention tests were described as mean and standard deviation. The improvement of the test scores was analysed using paired t-test in both the test and control groups. Postinterventional scores of both groups were compared. Feedback score was described in percentage. Comments and suggestions were noted.

RESULTS

In the present study, the mean age of the students in years was 19.07±0.69 and 19.1±0.71 for the intervention and non intervention groups respectively. The number of males and females in the intervention group were 52 and 57 in a ratio 1: 1.1 and the same in the non intervention group was 49 and 60 in a ratio 1:1.2. The pretest scores of both groups were comparable. Post-test scores showed a statistically significant difference between groups (student t-test, p<0.05) [Table/Fig-4]. There was a significant improvement in knowledge scores in the intervention group compared to the non intervention group (student t-test, p-value<0.003) [Table/Fig-5].

Parameters	Intervention group (n=109) Mean±Sd	Non intervention Group (n=109) Mean±Sd	Student t-test t	Student t-test p
Pretest	1.02±0.74	1.06±0.75	-0.367	0.714
Post-test	5.85±1.92	5.05±2.08	2.956	0.003
Paired t-test p-value	<0.001	<0.001		

[Table/Fig-4]: Pretest and Post-test scores of two groups.

Parameters	Improvement in Knowledge score Mean±SD	Student t-test t	Student t-test p
Intervention group (n=109)	4.83±2.00	3.053	0.003
Non intervention group (n=109)	3.99±2.06		

[Table/Fig-5]: Improvement in the knowledge score in the two groups.

It was observed that 99.1% of students mentioned this method as satisfactory and appreciated the benefit of using a series of models in making the concepts clear. While 85.8% of students felt it as more interactive, 96.8% got a better understanding of the topic and found it useful to solve confusion related to the topic. The duration given for handling models was not adequate for 68.1% of students [Table/Fig-6].

Students' responses to the open-ended question asking for any observation regarding the use of models included the following remarks.

1. PowerPoint is rather confusing because the cross sections at different levels are difficult to grasp at first look.
2. Got a better 3D picture of embryonic development.
3. Models were impressive and they made it easy to remember the 'week of twos'.
4. Easy to understand
5. Cavities well understood
6. Spatial understanding of germ layers is better.
7. Much better than the videos and diagrams for understanding the changes.
8. Able to visualise the second week's changes more perfectly.
9. No need to memorise the events.
10. Handmade models are better than synthetic models because that itself generates interest among students.

DISCUSSION

Theory hours are preferred for teaching embryology over practical hours, due to limited hours for embryology in the curriculum and large class size. For beginners, visualisation of the three-dimensional concept of the developing embryo with its related developmental processes within a short time becomes a tedious and time-consuming experience. [8].

Newer technologies that include simulation methods, Virtual Reality (VR), simulation-based screens or 3D printed models may not be available or used universally [5]. Expensive 3D embryology learning modules prompt many institutions to stay away from these resources [2,5]. There are studies available incorporating non digital, physical models which report the significant role of physical models in teaching anatomy in spite of the increasing availability of 3D web-based and computer-based models [3,9-11]. The models available in the department museums will be usually a single model representing a particular stage or week, which will not be suitable to deliver or understand the sequence of changes happening in the embryo. The material by which they are made is also heavy most of the time and not suitable for frequent, rough handling by the students and faculties. In such situations, cheaper handmade models can to a great extent be substitutes for the costly digital embryology platforms [5]. The incorporation of low-cost effective models is not a newer concept. Teaching with these models can be done synchronously with dissection or small group discussions.

Handmade models may be of two broad categories; either prepared and performed by competent faculty themselves or prepared under guidance by the students as part of their academic program [12,13]. But the creation of models requires the expression of psychomotor skill and imparts both implicit and explicit knowledge and provides three-dimensional information about the topic concerned [14]. Some students respond negatively to learning by making models, as they are not skilled in handcraft or the time consumed for this process is apparently more than the time spent by them for effective learning of the same topic without relying on models [15]. So, authors concentrated on teaching with instructor-designed low-cost models.

Ribaupierre S et al., noticed the influence of models in gaining spatial awareness [8]. Authors method of teaching with hand-made models provides more room for the generation of 3D concepts of embryological events which are otherwise difficult to attain. This can be simultaneously used for induction of learning embryology as well as for the later reassessment of the knowledge they gained, which in turn provides an index of the efficiency of the proposed teaching exercise. Visual, auditory, and tactile sensations that the students achieve by using models will stimulate a lot of neuronal circuits within the brain that will augment the consolidation of long-term memory [16].

Questions		Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)
Q1	Satisfied with model-assisted learning	0	0	2 (0.9)	97 (44.5)	119 (54.6)
Q2	Better Understanding of the topic	0	0	7 (3.2)	95 (43.6)	116 (53.2)
Q3	Learning made more Interactive	0	7 (3.2)	24 (11)	102 (46.8)	85 (39)
Q4	Made the topic interesting	0	2 (0.9)	13 (5.9)	79 (36.2)	124 (56.9)
Q5	The duration given for handling models is adequate	7 (3)	19 (8.7)	44 (20)	104 (48.1)	44 (20)
Q6	The Series of models made the concept clear	0	0	2 (0.9)	102 (46.8)	114 (52.3)
Q7	Attitude toward learning is changed	0	2 (0.9)	37 (17)	113 (51.8)	66 (30.3)
Q8	Helps to solve confusion on the topic	0	0	7 (3.2)	75(34.4)	136 (62.4)
Q9	Need such model-assisted lectures in other anatomy topics	0	0	2 (0.9)	10 (4.6)	206 (94.5)
Q10	Need such model-assisted lectures in other subjects	2 (0.9)	5 (2.3)	8 (3.7)	26 (11.9)	177 (81.2)

[Table/Fig-5]: The responses of students towards the model-based learning (n=number of responses).

The initial weeks of embryogenesis, especially the second week which is called the "week of twos" demonstrates a series of sequential and partially overlapping developmental events. This week entails the transformation of morula to germ disc and the evolvement of two cavities (amniotic cavity and yolk sac), two germ layers (ectoderm and endoderm), two divisions of trophoblast and two divisions of extra-embryonic mesoderm (somatopleuric and splanchnopleuric) [17]. To bridge the lacuna existing in didactic lectures and to simplify the learning of this complex mechanism of development, the current model-based teaching strategy was introduced.

In the present study, a statistically significant improvement was noted in the knowledge score of the intervention group. A positive influence of spatial visualization and spatial relation abilities of students on their performance was observed [18]. A remarkably good percentage of students were satisfied by the demonstration using models (99.1%). This was in accordance with the studies done by Oh CS et al., [15]. Also, a series of models showing the event-by-event progress in the developmental process was well accepted by the students, with a score of 99.1%. So, it was apparent that the introduction of models to the teaching process serves the purpose of delivering the concepts clearly.

In our study, the lecture was covered in one hour for both interventional and non interventional groups for the purpose of comparison. Thomas Huk in his study stated that students with a high spatial ability would benefit from 3D models [19]. The low spatial ability students became cognitively overloaded by these models and appeared stressed. They observed a more prolonged use of 3D models by low spatial ability students than by students with high spatial ability. Around 10% of students in our study group opined that it would have been better if more time was allowed to handle the models. This may be due to the difference in the level of spatial ability of the participants [20].

Students appreciated the need for such models in other anatomy topics also. This type of interactive session allows discussions, reducing the monotony of passive learning and increasing their interest in the subject [21]. Studies have shown that such sequential learning styles through different modalities of teaching like demonstrations and diagrams are preferred by students [22]. To know the efficacy of the intervention on the target group and to assess its effect on immediate retention, the proposed assessment was done just after the completion of the session. The long-term assessment was not done as it was assumed that the results would be influenced and altered depending on the possibility of acquiring additional information from various sources like textbooks or educational videos.

One of the advantages of this study is the possibility of the students getting triggered to make similar models on their own singly or in small groups as the materials used are readily available to them. Another advantage of these handmade models is that it can be considered for use in Objective Structured Clinical Examination (OSCE) stations for conducting formative or summative assessments [5]. The commercially available models are generally not so handy and are expensive, that the examiner may hesitate to pass it to the student, whereas our models can be handled easily and frequently.

Limitation(s)

The difference in the level of response may become more apparent and demonstrable if the sessions were carried out with a greater number of models-in-sequences taking more time for demonstration and handling by the students. Time constraints for such detailed demonstrations with models representing the whole embryonic period as well as the fact that periodic assessment of the students to test the contrast between the short-term and long-term retention was not done.

CONCLUSION(S)

Whether technically advanced or technology-assisted, the ultimate goal of teaching is to enhance learning. The introduction of low-cost handy models motivated the students and gave them a better understanding of the three-dimensional structure and related developmental processes of embryos in the earlier weeks of intrauterine life. This method changed their attitude toward learning embryology

Acknowledgment

Authors would like to thank the first MBBS students of 2019 batch in Government Medical College, Thiruvananthapuram, who participated and provided feedback in this interventional study. The authors gratefully acknowledge Dr. Priti Chaudhary and Dr. K Arora, Dr. SK Dhir for permitting us to use the feedback questionnaire. Authors are extremely thankful to our senior scientific officer Dr. Chandramohan Nair and other faculty in the Department of Anatomy for their guidance and support.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 09, 2022
- Manual Googling: Oct 25, 2022
- iThenticate Software: Nov 03, 2022 (5%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jul 30, 2022**
Date of Peer Review: **Sep 05, 2022**
Date of Acceptance: **Nov 04, 2022**
Date of Publishing: **Jan 01, 2023**